Mourning Dove Nesting: Seasonal Patterns and Effects of September Hunting

I.A.F.W.A.

UNITED STATES DEPARTMENT OF THE INTERIOR
Fish and Wildlife Service / *Resource Publication* 168

Resource Publication

This publication of the Fish and Wildlife Service is one of a series of semitechnical or instructional materials dealing with investigations related to wildlife and fish. Each is published as a separate paper. The Service distributes a limited number of these reports for the use of Federal and State agencies and cooperators. A list of recent issues appears on inside back cover.

Copies of this publication may be obtained from the Publications Unit, U.S. Fish and Wildlife Service, Matomic Building, Room 148, Washington, DC 20240, or may be purchased from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161.

Library of Congress Cataloging-in-Publication Data

Mourning dove nesting.

(Resource publication / United States Department of the Interior, Fish and Wildlife Service ; 168)
Supt. of Docs. no.: I 49.66:168
1. Mourning dove—Nests. 2. Mourning dove shooting. I. Geissler, Paul H. II. Series: Resource publication (U.S. Fish and Wildlife Service) ; 168.
S914.A3 no. 168 333.95′4′0973 s 87-600316
[QL696.C63] [598′.65]

Cover illustration. The three emblems represent the U.S. Department of Interior, Fish and Wildlife Service, and International Association of Fish and Wildlife Agencies. These agencies participated in studies of the nesting mourning dove portrayed on the cover. T. H. Kelley, artist.

Mourning Dove Nesting: Seasonal Patterns and Effects of September Hunting

By Paul H. Geissler
David D. Dolton
Rebecca Field
Richard A. Coon
H. Franklin Percival

Don W. Hayne
Lawrence D. Soileau
Ronnie R. George
James H. Dunks
S. Dwight Bunnell

A report of studies conducted jointly by the U.S. Fish and Wildlife Service and International Association of Fish and Wildlife Agencies.

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Resource Publication 168
Washington, DC • 1987

Cooperating Agencies

Alabama Department of Conservation and Natural Resources
Auburn University—Department of Zoology-Entomology
California Department of Fish and Game
Colorado Division of Wildlife
Florida Game and Fresh Water Fish Commission
Georgia Department of Natural Resources
Illinois Department of Conservation
Iowa Department of Natural Resources
Kentucky Department of Fish and Wildlife Resources
Louisiana Department of Wildlife and Fisheries
Maryland Department of Natural Resources
Mississippi Game and Fish Commission
Mississippi State University—Department of Wildlife and Fisheries
Missouri Department of Conservation
Nebraska Game and Parks Commission
New Mexico Game and Fish Department
North Carolina Wildlife Resources Commission
Oklahoma Department of Wildlife Conservation
Pennsylvania Game Commission
South Carolina Wildlife and Marine Resources Department
Tennessee Wildlife Resources Agency
Texas A&M University—Department of Wildlife and Fisheries Sciences
Texas Parks and Wildlife Department
University of Florida—School of Forest Resources and Conservation
University of Tennessee—Department of Forestry, Wildlife and Fisheries
U.S. Fish and Wildlife Service
- Patuxent Wildlife Research Center
- Migratory Bird and Habitat Research Laboratory
- Office of Migratory Bird Management
- Regions 2, 3, 4, 5, and 6
- Division of Animal Damage Control
- Office of Wildlife Assistance
- Division of Refuge Management
- Office of Cooperative Research Units

Utah Division of Wildlife Resources
Virginia Commission of Game and Inland Fisheries
Virginia Polytechnic Institute and State University—Department of Fisheries and Wildlife Sciences
West Virginia Department of Natural Resources

Contents

Preface

Mourning dove hunting is a popular sport for many Americans. Regulations permitting September hunting have been in effect since passage of the Migratory Bird Treaty Act of 1918. In recent years, seasons have started in September in most States where dove hunting is permitted. Some individuals and organizations were concerned that September hunting of adult birds results in substantial mortality of young still in the nest and reduced nesting activity due to disturbance. To allay these concerns, the U.S. Fish and Wildlife Service, 23 State wildlife agencies, and 6 State universities conducted this major cooperative study of mourning dove nesting. The results reported in this volume provide assurance that September dove hunting, under regulations prevailing during the period of the study, does not have any measurable effect on mourning dove reproduction nationwide.

This research effort demonstrated the responsiveness of Federal and State agencies to public concern for the welfare of the Nation's migratory bird populations and speaks well for the shared responsibility for our scientific management of fish and wildlife resources. The U.S. Fish and Wildlife Service and the International Association of Fish and Wildlife Agencies are pleased to jointly sponsor this work and provide this publication.

Robert M. Brantly, President
International Association of Fish
and Wildlife Agencies

Frank H. Dunkle, Director
U.S. Fish and Wildlife Service

Mourning Dove Nesting: Seasonal Patterns and Effects of September Hunting

by

Paul H. Geissler
U.S. Fish and Wildlife Service
Patuxent Wildlife Research Center
Laurel, Maryland 20708

David D. Dolton
U.S. Fish and Wildlife Service
Migratory Bird Management Office
Laurel, Maryland 20708

Rebecca Field[1], Richard A. Coon[2], and H. Franklin Percival[3]
U.S. Fish and Wildlife Service
Patuxent Wildlife Research Center
Laurel, Maryland 20708

Don W. Hayne
North Carolina State University
Raleigh, North Carolina 27695

Lawrence D. Soileau
Louisiana Department of Wildlife and Fisheries
Opelousas, Louisiana 70570

Ronnie R. George[4]
Iowa Department of Natural Resources
Chariton, Iowa 50049

James H. Dunks[5]
Texas Parks and Wildlife Department
Austin, Texas 78744

S. Dwight Bunnell
Utah Division of Wildlife Resources
Salt Lake City, Utah 84116

[1]Present address: U.S. Fish and Wildlife Service, Department of the Interior, Office of Special Studies, 1011 East Tudor Rd., Anchorage, Alaska 99503.

[2]Present address: U.S. Fish and Wildlife Service, Department of the Interior, Washington, D.C. 20240.

[3]Present address: Florida Cooperative Fish and Wildlife Research Unit, U.S. Fish and Wildlife Service, 117 Newins-Ziegler Hall, University of Florida, Gainesville, Fla. 32611.

[4]Present address: Texas Parks and Wildlife Department, 4200 Smith School Rd., Austin, Tex. 78744.

[5]Present address: Ducks Unlimited, Inc., 7806 Phoenix Pass, Austin, Tex. 78737.

Abstract

A nationwide State–Federal cooperative study was initiated in 1978 to examine effects of September hunting on nesting mourning doves (*Zenaida macroura*). This study was designed to (1) determine the proportion of the annual total of dove nesting activity and production that occurs in September and October, and (2) determine if survival rates of mourning dove eggs and nestlings are lower in zones where early September dove hunting is permitted than in zones where it is prohibited.

During 1979 and 1980, 6,950 active nests were monitored to obtain data on nesting patterns. Nest initiation was estimated using two measurements, backdating from hatch dates and counting numbers of nests found for the first time. The nationwide percentage of the annual total of nests that were initiated in September and October was 1.0% based on backdating from hatch dates and 2.7% based on nests found for the first time. Nesting activity was measured by numbers of eggs and nestlings present in weekly counts. Nationally, 4.5% of the annual nesting activity occurred in September and October. The activity of 80% of the observed nests was within the period of 22 April to 4 September. The measure of production used in this study was numbers of young fledged. Nationally, 10.3% of all observed fledging occurred in September and October. Because a decline in nests found in the latter half of the nesting season preceded the 1 September start of hunting, we concluded that the reduction in nesting activity at the end of the season is a natural phenomenon and is not caused by hunting disturbance.

In a separate part of this study, we estimated survival rates in adjacent hunted and nonhunted zones from data on 668 nests. The estimated daily survival rates for individual eggs and nestlings were 95.8% in the nonhunted and 95.0% in the hunted zones; the corresponding fledging rates were 33 and 26%, respectively. The fledging rates are lower because they are the daily survival rates operating over a 26-day nesting period. Neither differences in survival nor fledging rates between nonhunted and hunted zones were found to be statistically significant ($P > 0.05$). We determined that the statistical test was powerful enough to detect a reduction due to hunting from a hypothetical 96.0 to 94.2% in daily nestling survival rates (from 35 to 21% in fledging rates) with 80% probability. An undetected reduction in fledging rate of that magnitude would probably reduce the overall fledging rate by less than 1 percentage point, because only a small proportion of the nesting doves are exposed to hunting for the full 26-day nesting cycle.

In conclusion, we found that only a small proportion of total annual nesting attempts occurred after the start of hunting season. There was no statistically significant difference in survival rates in zones where hunting was permitted compared with zones where it was prohibited. We concluded from this study that dove hunting under current regulations has no substantial effect on recruitment of fledglings into the mourning dove population.

The mourning dove (*Zenaida macroura*) is one of the most abundant birds in the United States (Robbins and Van Velzen 1969). Estimated fall populations have ranged from 350 to 600 million doves (U.S. Fish and Wildlife Service 1975; Dunks 1977; Dunks et al. 1982; R. E. Tomlinson, unpublished report). The species has a long nesting season and a nationwide nesting range. Based on a review of 45 studies, most nesting activity in the United States occurs between March and September (U.S. Fish and Wildlife Service 1977). The dove breeds throughout all 48 conterminous States, as well as in southern Canada, northern Mexico, and the Greater Antilles (Aldrich and Duvall 1958; Keeler 1977).

Dove hunting is a popular and traditional recreation for about 2 million people (Keeler 1977). During an estimated 11.4 million hunting trips per year, about 49 million doves are taken with substantial outlay of recreational time and cost by the hunter

(Keeler 1977). The dove hunting season is one of the earliest game seasons to open. Regulation frameworks permitting hunting in September have been in effect since passage of the Migratory Bird Treaty Act of 1918. During the 1981 hunting season, 33 of the 34 States permitting dove hunting opened the season in September.

Because States may open their dove hunting seasons in September when doves may still be nesting, some individuals and organizations have opposed Federal regulations permitting September hunting. It has been asserted that hunting mortality of breeding adults during this period results in substantial mortality of eggs and nestlings and that hunting disturbance leads to a reduction in nesting activity (McClure 1950; Schroeder 1970).

In an environmental assessment, the U.S. Fish and Wildlife Service concluded that regulations permitting September hunting have negligible adverse impact on the maintenance of mourning dove populations in the United States (U.S. Fish and Wildlife Service 1977). However, no field studies had been conducted that compared dove production in hunted and nonhunted zones, nor were standardized and coordinated data available to show seasonal dove nesting patterns throughout the United States. If September hunting has an adverse impact on the maintenance of mourning dove populations through mortality of eggs and nestlings or reduction in nesting activity, the effect would depend on the amount of nesting activity that naturally occurs in September, length of exposure of these nests to effects of hunting, and effects of hunting on survival of eggs and nestlings.

The present study was initiated in late summer 1978 to provide information about the effects of September hunting on late-season nesting of mourning doves. The objectives of the study were to (1) determine the proportion of the annual total of mourning dove nesting activity and production that occurs in September and October, and (2) determine if survival rates of mourning dove nests and of individual eggs and nestlings are lower in zones where early September dove hunting is permitted compared with nearby zones where it is prohibited.

These objectives were addressed in two separate parts of the study. The data were collected in different areas at different times and with different personnel. Therefore, we present methods and results separately for each part. The discussion and conclusions address both objectives. This study was a cooperative effort among State wildlife agencies, State universities, and the U.S. Fish and Wildlife Service. Some States have analyzed their parts of the national data separately (Hughes 1981; Mirarchi and Hudson 1981; Pearce 1981; Burch 1982; Marion and Schnoes 1982).

Part I. Seasonal Nesting Patterns

The first objective of the present study was to estimate the proportion of all mourning dove nesting activity and production that occurs in September and October, and to examine seasonal changes in survival of eggs and nestlings.

Study Areas

A total of 106 study areas were established in 27 States (Fig. 1). The sizes of the study areas were variable and the shapes often irregular; they were determined by the amount of the habitat that an observer could search thoroughly in one 6-h search day each week with an additional 2 h for checking previously located nests. After the study areas were selected, their sizes remained unchanged throughout the search period.

By necessity, study areas were chosen for proximity to cooperators and therefore could not be selected randomly. Efforts were made to select areas typical of good dove nesting habitat. The nonrandom selection makes it necessary to use care in generalizing results of this study.

Methods

Nest Observations

Weekly nest searches were carried out from February through October in 1979 and 1980 to locate nests and record the status of previously located nests. Nesting during November through January was assumed to be negligible.

An active dove nest was defined as one containing one or more eggs or nestlings. If unhatched eggs were present after 16 days of observation or if a second egg was present 2 days after the first hatched, we assumed mortality for the egg(s). Each active nest was visited weekly through the 10th day after hatching, or until eggs or nestlings disappeared or

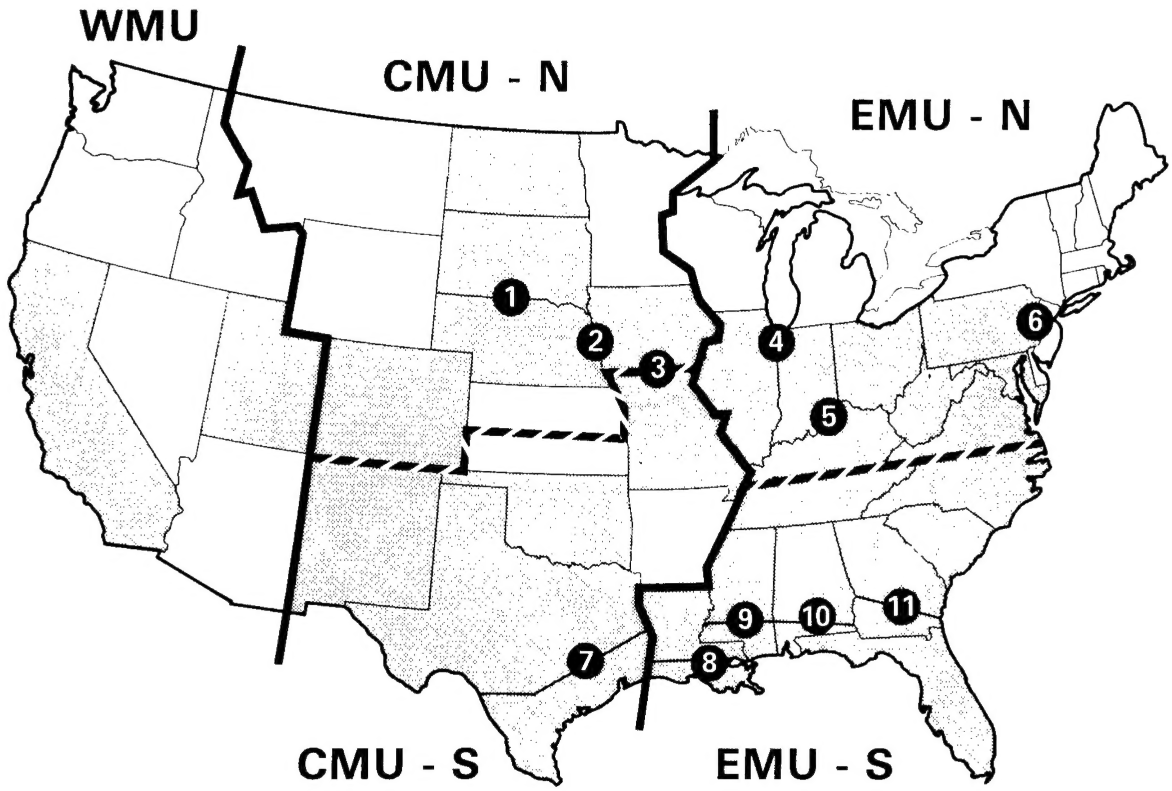


Fig. 1. Location of study areas. *Shaded* States contain study areas for the first part of the study, determining annual patterns in nesting activity. *Circled* numbers indicate location of hunted–nonhunted boundaries that divide the study areas used in the second part, assessing the effects of hunting. *Heavy lines* denote the Eastern (EMU), Central (CMU), and Western (WMU) Management Units; *dashed lines* show north (N) and south (S) subdivisions.

were destroyed. A special effort was made to visit the nests on the 10th day after hatching because we defined fledging as survival through that day. Although the usual age of fledging is 12 days after hatching (Hanson and Kossack 1963), 10 days represent the earliest that dove nestlings can be expected to survive after leaving the nest. The fate of a nest found empty after day 10 could not be evaluated accurately because nestlings could have either fledged or been destroyed. The age of nestlings was estimated following techniques described by Hanson and Kossack (1963).

Analyses

Because of possible latitudinal differences in breeding biology, the Eastern Management Unit and the Central Management Unit were divided arbitrarily into northern and southern sections (EMU-N, EMU-S, CMU-N, and CMU-S; Fig. 1); this is not to suggest that these divisions should be established for management purposes. The Western Management Unit (WMU), with only two States in the sample, was not divided.

Estimates for all variables were obtained by pooling data within each of three geographic categories: the United States, management unit divisions, and States—in effect weighting each State by its sample size. The States involved in the study were considered a sample from all States. We based the 95% confidence limits for these estimates for the United States and management unit divisions on the variance of the constituent State estimates, using an angular transformation where the variable was a percentage (Snedecor and Cochran 1980). National

estimates for all variables were calculated both with and without weighting the management unit division estimates by the breeding density indices (Dolton 1980). The weighting might adjust for sampling that may not have been proportional to the dove population in those divisions. The weighted estimates are not included in the results because they were so similar to the unweighted estimates.

The weekly proportion of the annual total of nests found for the first time served as an approximation of nest initiation. Nests first found in early September may have been initiated in late August, making the measure of nests first found an overestimate of nest initiation in September and October. Therefore we used an additional estimate of nest initiation that was based on backdating from the date of the first egg hatched in the nest. This estimate assumes that the egg survival rate is the same in September and October as it is in other months. The weekly proportion of the annual total count of individual eggs and nestlings present on the study areas was used as a measure of nesting activity.

Hatch dates were used in this study to define the nesting season because they were the most accurately determined biological event in the nesting cycle. We calculated the 10th, 25th, 50th (median), 75th, and 90th percentiles of hatch dates. The length of the nesting season was defined for the purposes of this study as the number of days between the 10th and 90th percentiles. The period when 80% of the nests were active was estimated by subtracting a 14-day incubation period from the 10th percentile and adding a 12-day nestling period to the 90th percentile.

Production was measured by the number of doves fledged. The weekly proportion of the annual total of nests found for the first time served as an indicator of subsequent trends in production.

We estimated daily survival rates and fledging rates by using the Mayfield method (Mayfield 1961, 1975; Miller and Johnson 1978; Johnson 1979; Hensler and Nichols 1981; see Appendix A). By including the time span of observation, the Mayfield method produces a more reliable estimate of survival than the alternate method of calculating fledging rates (dividing the number of individuals fledged by the number of individuals present when the nest was found).

The variables were analyzed by using analyses of variance (SAS type IV hypotheses, Ray 1982). Each statistic was calculated for each combination of State, year, and season. These statistics were used as independent observations in the analyses. To assure adequate sample sizes, we combined data for the following State pairs: Indiana and Illinois, Ohio and Pennsylvania, and West Virginia and Virginia.

The seasons were defined for most variables as spring (February through April; weeks 5–18); summer (May through August; weeks 19–35); and fall (September and October; weeks 36–44). Summer was divided into early summer (May and June; weeks 19–26) and late summer (July and August; weeks 27–35) for the analysis of daily survival rate because the sample size permitted a more detailed examination of survival during these seasons. Weeks started on Mondays with week 1 for the 2 years beginning 1 January 1979 and 31 December 1979, respectively.

For all response variables, the 4 degrees of freedom for divisions of dove management units were divided into 4 single degrees of freedom contrasts: north versus south of EMU and CMU; EMU versus CMU; north–south by EMU–CMU interaction; and WMU versus the other divisions. For daily survival rate, 3 degrees of freedom for the four seasons were separated into single degrees of freedom contrasts for summer versus fall, spring versus summer, and early versus late summer.

Proportions in spring, summer, and fall were analyzed separately for each of the following variables: nests first found, eggs laid, individuals present, and individuals fledged. We transformed these variables and the daily survival rate using an angular transformation (Snedecor and Cochran 1980); the analysis was weighted by the denominator of the proportion. The 10th, 50th, and 90th percentiles of hatch dates and length of nesting season were not transformed.

In calculating the number of young doves fledged, we found that 31.3% of the nests were not checked by the observer on the 10th day after hatching. In order to use this important fraction of the data, we made a reasonable estimate of the number that would be expected to fledge in this situation. The estimate was NS^d, where N = number of nestlings in nest; S = daily survival rate of nestlings; and d = number of days until nestlings reach 10 days of age. For this extrapolation, we used separate daily survival rates for each management unit division and each season (determined by date of the last nest check). To provide an adequate sample size in the CMU-N for calculating the daily survival rates used in this extrapolation, we combined CMU-N with EMU-N for the spring season.

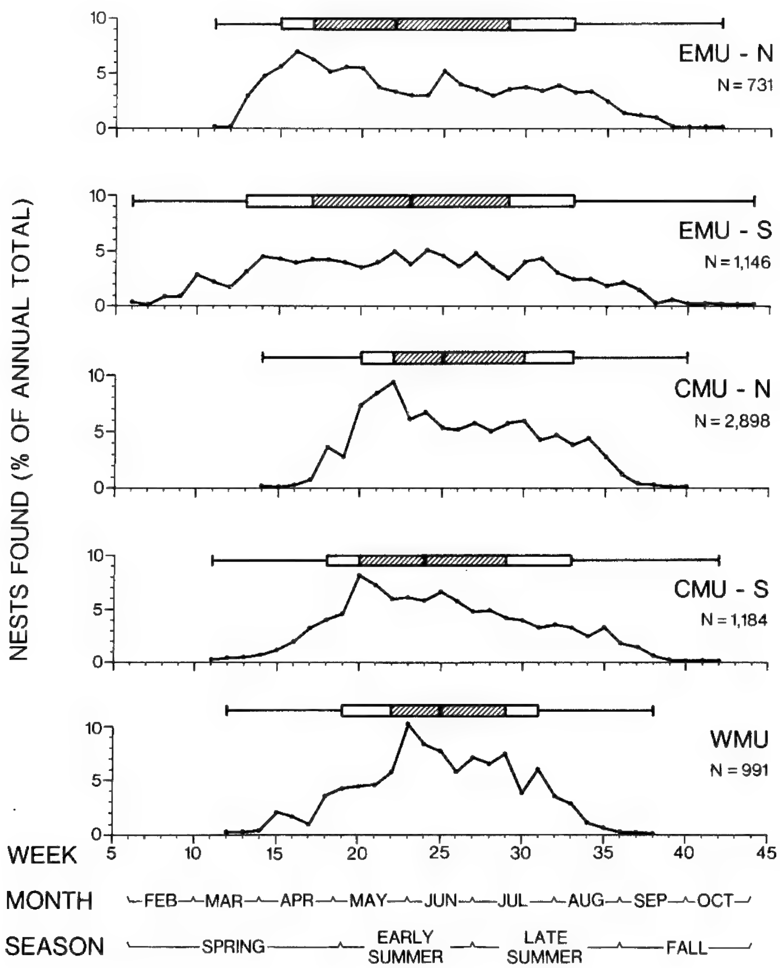


Fig. 2. Nests first found each week expressed as percentages of an annual total from combined 1979 and 1980 data for mourning dove management unit divisions. Endpoints of horizontal lines on the box plot represent maximum and minimum dates. The entire box plot shows 80% of the total, with the shaded area representing 50% of the total about the median.

Results

Observations of 6,950 active nests were used in the analyses: 3,307 in 1979 and 3,643 in 1980 (Appendix B).

Nest Initiation

The number of nests found for the first time on each weekly visit was used to approximate patterns of nest initiation (Fig. 2; Table 1; Appendix C). A discussion of the use of this measure as an indicator of later trends in potential production follows. Nest initiation was also estimated by backdating from hatch dates (Table 2).

Based on nests first found nationwide, we estimated that 2.7% (1.6–4.0%, 95% confidence interval) of the annual total of nest initiation occurred in September and October. Pooled estimates are stated on original scale with back-transformed 95% confidence intervals. The estimates for the divisions of the management units were EMU-N 4.0% (0.1–6.6%), EMU-S 4.8% (3.1–8.3%), CMU-N 1.9% (0.7–2.7%), CMU-S 3.9% (0–10.4%), and WMU 0.5% (0–2.3%).

With nests first found, a greater proportion were initiated during spring and a smaller proportion during summer in the EMU compared with the CMU ($P < 0.001$). A greater proportion of the nests were initiated in summer ($P < 0.01$), and a smaller proportion in spring ($P < 0.05$) and fall ($P < 0.01$) in the WMU compared with the EMU and CMU.

Based on backdating the hatch dates, we estimated that 1.0% (0.3–1.7%) of the annual total of nest initiation in the United States occurred in September and October. The estimates for divisions of the management units were EMU-N 2.9%

Table 1. *Analysis of variance and pooled estimates of seasonal percent of annual total of nests first found (Spring = February through April; Summer = May through August; Fall = September and October). Indention indicates the subdivision of a source. Levels of significance: * = (0.10 > P > 0.05), ** = (0.05 > P > 0.01), *** = (0.01 > P > 0.001), **** = (0.001 > P), and — = (P > 0.10). Mean squares are given in Appendix I(1).*

Source	Analysis of variance: Degrees of freedom	Spring	Summer	Fall
Management unit division	4	****	****	**
North vs. south (EMU & CMU)	1	—	—	—
EMU vs. CMU	1	****	****	—
(North vs. south)*(EMU vs. CMU)	1	—	—	—
WMU vs. other divisions	1	**	***	***
State within division (error for above)	19			

Season	Pooled estimates: EMU-N	EMU-S	CMU-N	CMU-S	WMU	US
Spring	31.9	33.2	4.6	12.4	9.3	14.2
Summer	64.1	62.0	93.5	83.7	90.2	83.1
Fall	4.0	4.8	1.9	3.9	0.5	2.7
No. nests	731	1,146	2,898	1,184	991	6,950

Table 2. *Analysis of variance and pooled estimates of seasonal percent of annual total of eggs laid (based on backdating from those eggs that survived to hatching) (Spring = February through April; Summer = May through August; Fall = September and October). Indention indicates the subdivision of a source. Levels of significance: * = (0.10 > P > 0.05), ** = (0.05 > P > 0.01), *** = (0.01 > P > 0.001), **** = (0.001 > P), and — = (P > 0.10). Mean squares are shown in Appendix I(2).*

Source	Analysis of variance: Degrees of freedom	Spring	Summer	Fall
Management unit division	4	***	****	****
North vs. south (EMU & CMU)	1	—	—	—
EMU vs. CMU	1	****	****	****
(North vs. south)*(EMU vs. CMU)	1	—	—	—
WMU vs. other divisions	1	—	*	***
State within division (error for above)	19			

Season	Pooled estimates: EMU-N	EMU-S	CMU-N	CMU-S	WMU	US
Spring	34.1	36.4	8.3	16.6	14.9	18.1
Summer	63.0	60.7	91.5	82.4	85.1	80.9
Fall	2.9	2.9	0.2	0.9	0.0	1.0
No. eggs	938	1,111	3,079	1,070	1,108	7,306

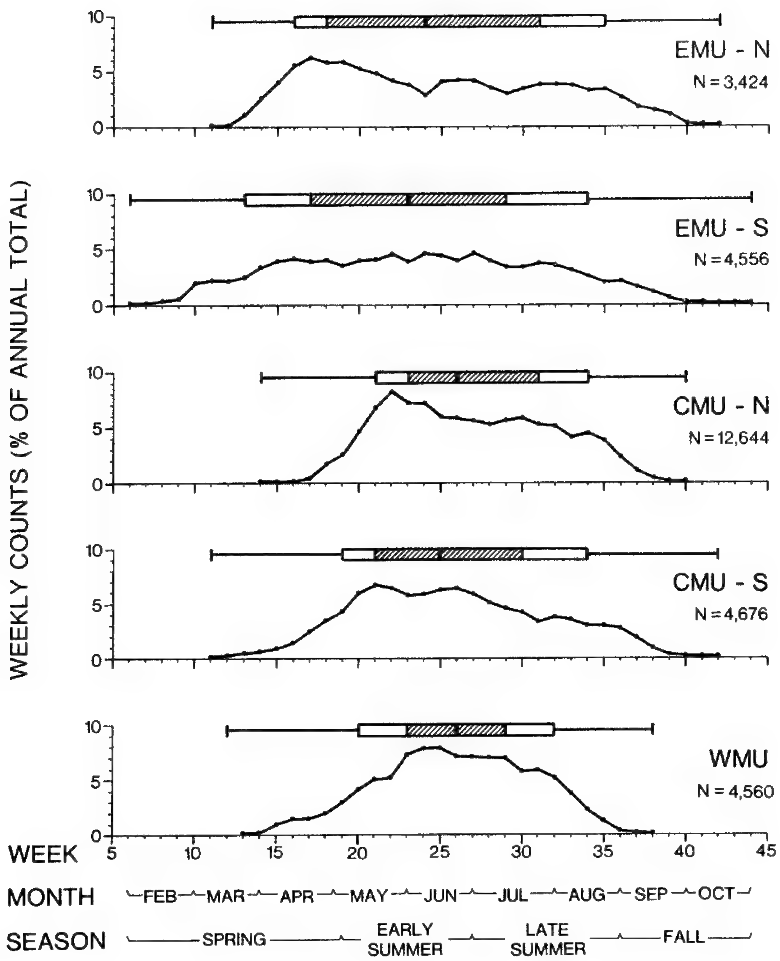


Fig. 3. Weekly counts of individual eggs or nestlings expressed as percentages of an annual total from combined 1979 and 1980 data for mourning dove management unit divisions. Endpoints of horizontal lines on the box plot represent maximum and minimum dates. The entire box plot shows 80% of the total, with the shaded area representing 50% of the total about the median.

(0–5.4%), EMU-S 2.9% (1.8–4.5%), CMU-N 0.2% (0–0.5%), CMU-S 0.9% (0–2.4%), and WMU 0%.

With back-dated hatch dates, greater proportions of nests were initiated in spring and fall, and a smaller proportion in summer in the EMU compared with the CMU ($P < 0.001$). The WMU had a smaller proportion of nests initiated in fall compared with the other management units ($P < 0.01$).

Nesting Activity

Nesting activity reflects the quantity and duration of all nesting behavior. It was measured by the numbers of individual eggs and nestlings present each week (Fig. 3; Table 3; Appendix C).

In the United States, 4.5% (2.8–5.9%) of the weekly counts of eggs and nestlings were in September and October. The estimates for the divisions of the management units were EMU-N 7.4% (0.2–11.7%), EMU-S 6.1% (4.5–9.5%), CMU-N 4.0% (2.5–5.0%), CMU-S 6.0% (0–13.6%), and WMU 0.6% (0–7.0%).

A greater proportion of individual eggs and nestlings were present in spring and a smaller proportion in summer in the EMU than in the CMU ($P < 0.001$). The WMU had a greater proportion of individuals present in summer ($P < 0.001$) and a smaller proportion in spring ($P < 0.05$) and fall ($P < 0.001$) than the rest of the country.

Table 3. *Analysis of variance and pooled estimates of seasonal percent of annual total of weekly counts of individual eggs or nestlings present (Spring = February through April; Summer = May through August; Fall = September and October). Indention indicates the subdivision of a source. Levels of significance: * = (0.10 >P > 0.05), ** = (0.05 >P > 0.01), *** = (0.01 >P > 0.001), **** = (0.001 >P), and — = (P > 0.10). Mean squares are shown in Appendix I(3).*

Source	Analysis of variance			
	Degrees of freedom	Spring	Summer	Fall
Management unit division	4	****	****	***
North vs. south (EMU & CMU)	1	*	*	—
EMU vs. CMU	1	****	****	—
(North vs. south)*(EMU vs. CMU)	1	—	—	—
WMU vs. other divisions	1	**	****	****
State within division (error for above)	19			

Season	Pooled estimates					
	EMU-N	EMU-S	CMU-N	CMU-S	WMU	US
Spring	25.5	30.2	2.4	9.8	6.3	11.0
Summer	67.1	63.7	93.6	84.2	93.1	84.5
Fall	7.4	6.1	4.0	6.0	0.6	4.5
Total count	3,424	4,556	12,644	4,676	4,560	29,860

Nesting Season

The nesting season was estimated from the hatch dates (Fig. 4; Table 4; Appendix D). Nationally, we found that 80% of the nests were active between 22 April and 4 September. The 95% confidence intervals on these dates are 4–25 April and 30 August–9 September.

The nesting season began earlier and lasted longer in the southern than in the northern parts of the EMU and CMU ($P < 0.05$). There was no evidence of a difference in end of the season ($P > 0.10$) in the southern and northern parts of these units.

The nesting season began earlier and lasted longer in the EMU than in the CMU ($P < 0.001$). Again, there was no evidence of a difference in end of the season in the two management units ($P > 0.10$). The median date of hatching in the EMU was earlier than the median date in the CMU ($P < 0.05$).

In the WMU, the nesting season began later and was shorter than in the other two management units ($P < 0.05$). No difference was evident in the end of the nesting season between WMU and other units ($P > 0.10$).

Production

Nesting activity does not necessarily reflect production of doves because high levels of nesting activity combined with low survival might result in low final production. The measure of production used was numbers of young fledged (Fig. 5; Table 5; Appendix C). In the United States, 10.2% (6.7–12.2%) of all fledging occurred in September and October. The estimates for the divisions of the management

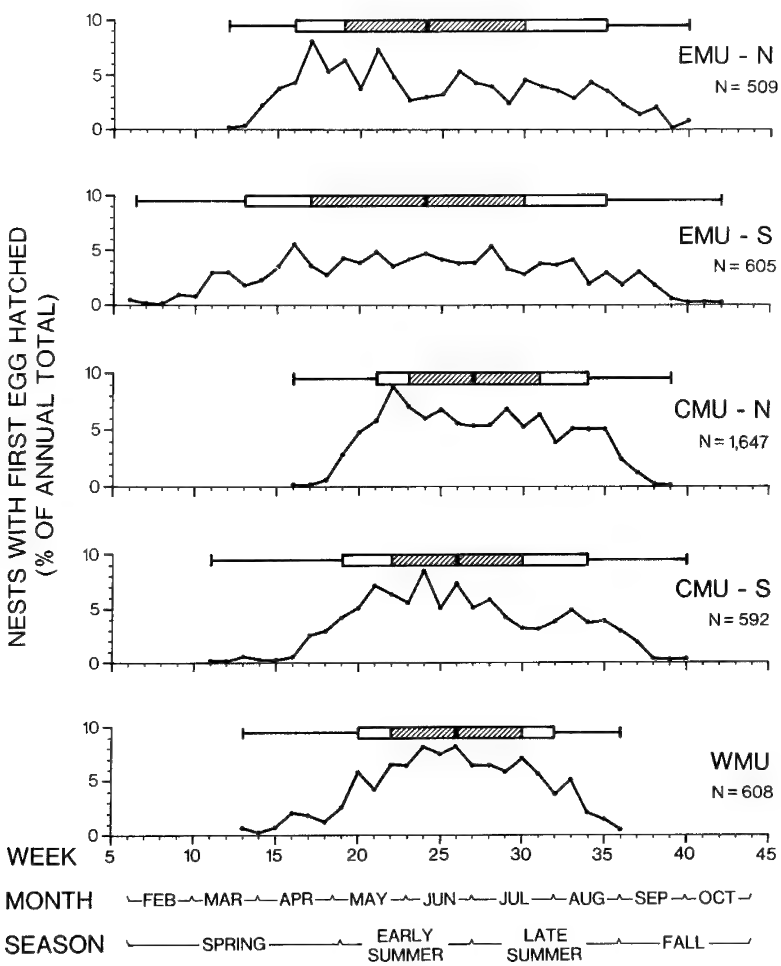


Fig. 4. Nests with the first egg hatched each week expressed as percentages of an annual total from combined 1979 and 1980 data for mourning dove management unit divisions. Endpoints of horizontal lines on the box plot represent maximum and minimum dates. The entire box plot shows 80% of the total, with the shaded area representing 50% of the total about the median.

Table 4. *Analysis of variance and pooled estimates for the 10th, 50th (median) and 90th percentiles of hatch dates for first egg in nests and the length of the nesting season. The nesting season is defined for the purpose of this report to be the number of days between the 10th and 90th percentile. Indention indicates the subdivision of a source. Levels of significance:* * = *(0.10 > P > 0.05)*, ** = *(0.05 > P > 0.01)*, *** = *(0.01 > P > 0.001)*, **** = *(0.001 > P), and* — = *(P > 0.10). Mean squares are given in Appendix I(4).*

Source	Degrees of freedom	10th Percentile	Median	90th Percentile	Length
	Analysis of variance				
Management unit division	4	****	*	—	****
North vs. south (EMU & CMU)	1	***	—	—	**
EMU vs. CMU	1	****	**	—	****
(North vs. south)*(EMU vs. CMU)	1	—	*	—	—
WMU vs. other units	1	**	—	—	**
State within division (error for above)	19				

Management unit division	10th Percentile	Median	90th Percentile	Length
	Pooled estimates			
EMU-N	21 Apr.	12 Jun.	26 Aug.	127
EMU-S	1 Apr.	12 Jun.	26 Aug.	148
CMU-N	23 May	4 Jul.	25 Aug.	94
CMU-S	11 May	25 Jun.	26 Aug.	107
WMU	13 May	26 Jun.	10 Aug.	89
US	6 May	26 Jun.	23 Aug.	109

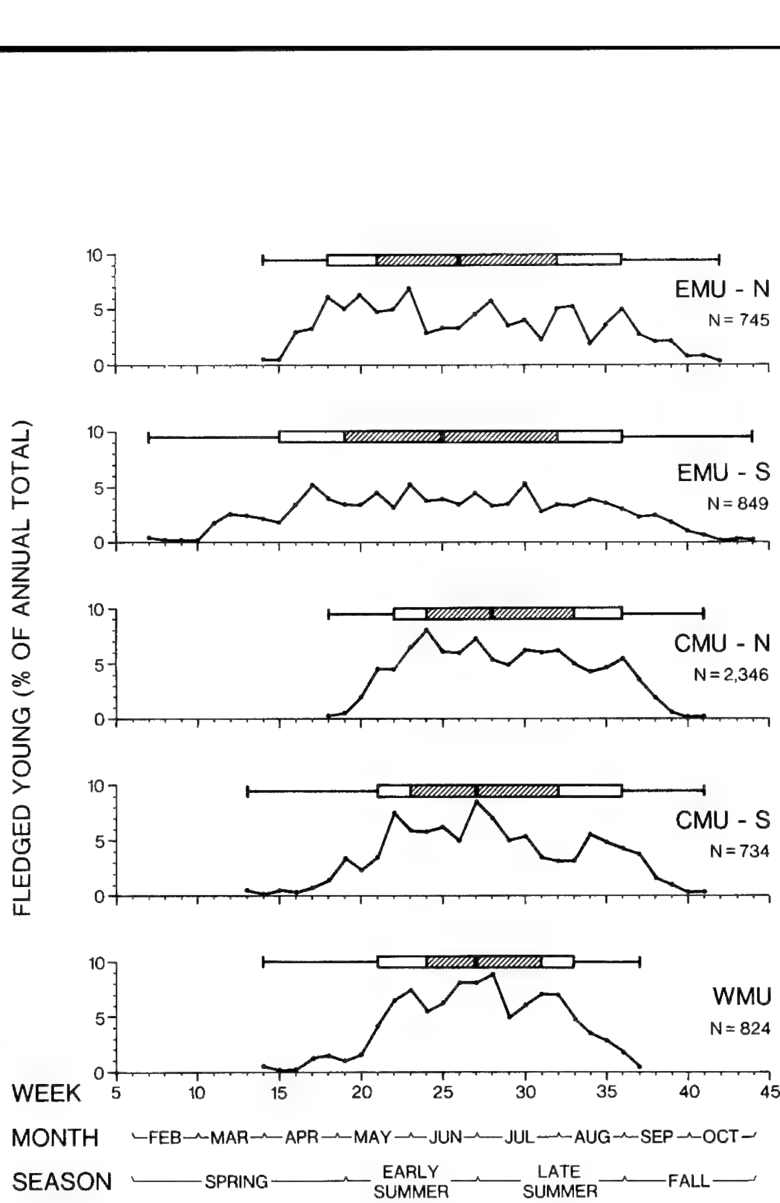


Fig. 5. Young fledged each week expressed as percentages of an annual total from combined 1979 and 1980 data for mourning dove management unit divisions. Endpoints of horizontal lines on the box plot represent maximum and minimum dates. The entire box plot shows 80% of the total, with the shaded area representing 50% of the total about the median.

Table 5. *Analysis of variance and pooled estimates of seasonal percent of annual total of doves fledged (Spring = February through April; Summer = May through August; Fall = September and October). Indention indicates the subdivision of a source. Levels of significance: * = (0.10 > P > 0.05), ** = (0.05 > P > 0.01), *** = (0.01 > P > 0.001), **** = (0.001 > P), and — = (P > 0.10). Mean squares are given in Appendix I(5).*

	Analysis of variance			
Source	Degrees of freedom	Spring	Summer	Fall
Management unit division	4	****	****	***
North vs. south (EMU & CMU)	1	**	*	—
EMU vs. CMU	1	****	****	—
(North vs. south)*(EMU vs. CMU)	1	—	—	—
WMU vs. other divisions	1	*	****	****
State within division (error for above)	19			

	Pooled estimates					
Season	EMU-N	EMU-S	CMU-N	CMU-S	WMU	US
Spring	13.4	24.2	0.2	3.4	3.9	6.6
Summer	73.2	64.3	88.5	85.4	93.9	83.1
Fall	13.4	11.5	11.3	11.2	2.2	10.2
No. fledged	745	849	2,346	734	824	5,498

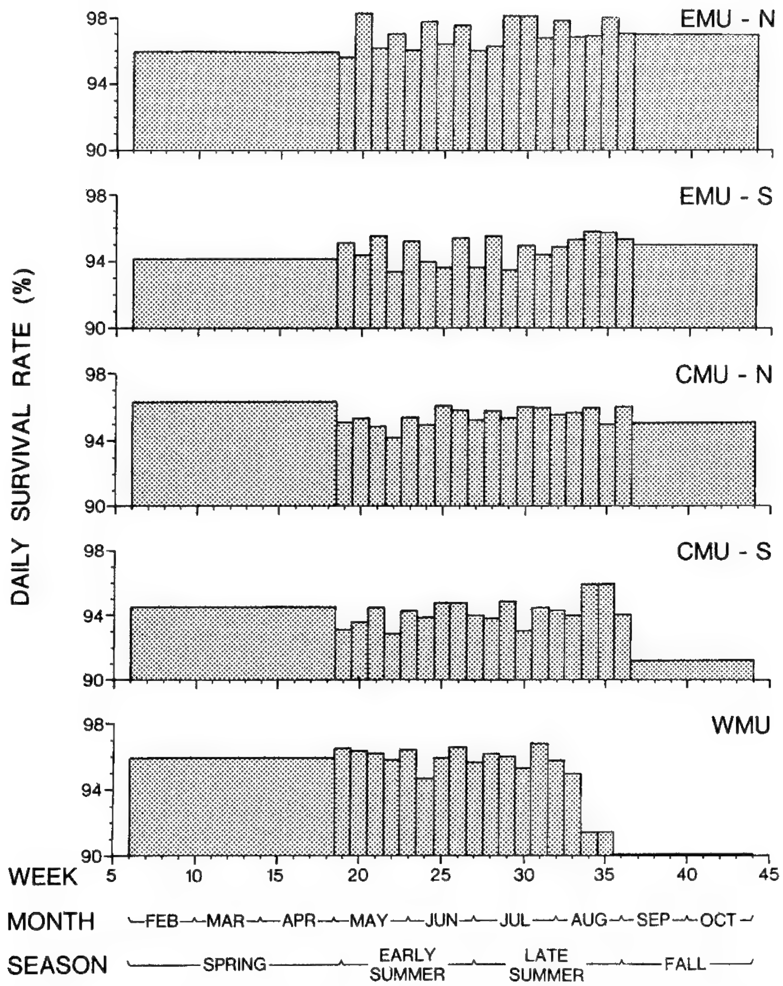


Fig. 6. Daily survival rates of individual eggs and nestlings each week from combined 1979 and 1980 data for mourning dove management unit divisions. Early and late weeks in the year are pooled to obtain larger sample sizes.

Table 6. *Analysis of variance and pooled estimates of daily survival rates of individual eggs and nestlings. Indention indicates the subdivision of a source. Levels of significance: * = (0.10 > P > 0.05), ** = (0.05 > P > 0.01), *** = (0.01 > P > 0.001), **** = (0.001 > P), and — = (P > 0.10). Mean squares are given in Appendix I(6).*

Source	Analysis of variance: Degrees of freedom	Analysis of variance: Daily survival rate
Management unit division	4	—
North vs. south (EMU & CMU)	1	**
EMU vs. CMU	1	*
(North vs. south)*(EMU vs. CMU)	1	—
WMU vs. other units	1	—
State within division (error for above)	19	
Season	3	—
Season*division	12	—
Season*State within division (error for above)	53	

Season	Pooled estimates: EMU-N	EMU-S	CMU-N	CMU-S	WMU	US
Spring	95.89	94.13	96.35	94.45	95.86	94.99
Early summer	96.83	94.54	95.16	93.96	95.97	95.18
Late summer	97.16	94.72	95.57	94.32	95.48	95.43
Fall	97.01	95.05	95.70	92.51	90.04	95.09
All seasons	96.71	94.50	95.39	94.07	95.71	95.26

units were EMU-N 13.4% (0.3–22.4%), EMU-S 11.5% (8.2–17.1%), CMU-N 11.3% (9.2–12.9%), CMU-S 11.2% (2.2–19.3%), and WMU 2.2% (1.5–3.0%).

A greater proportion of doves fledged in spring and a smaller proportion in summer in the EMU compared with the CMU ($P < 0.001$). A smaller proportion fledged in spring in the northern compared with the southern parts of the EMU and CMU ($P < 0.05$). A greater proportion fledged in summer and a smaller proportion in fall in the WMU compared with the other units ($P < 0.001$).

In the analyses for nests found, eggs laid, and individuals present, tests were made for differences between the northern and southern parts of the EMU and CMU and for the interaction between these differences and differences between EMU and CMU. These differences were not significant ($P > 0.05$).

Separate analyses of variance were carried out for nests found, eggs laid, individuals present, 10th percentile of hatch dates, length of nesting season, and individuals fledged. Each analysis tested for differences among years and for differences in the interaction of year and management unit division. These results are not reported in Tables 1–6 because only 1 of the 32 tests was significant at the 5% level; on the average, 1 out of 20 would be expected to be significant due to chance.

The number of nests found for the first time on each weekly visit serves as an indicator of subsequent trends in production (Fig. 2; Table 1; Appendix C). The decline in the number of new nests found in late August (Fig. 2) is, of course, independent of the effects of hunting, which starts on or after 1 September. Based on the August decline, we would expect a decrease in proportion of doves fledged in early September. Such a decrease can be

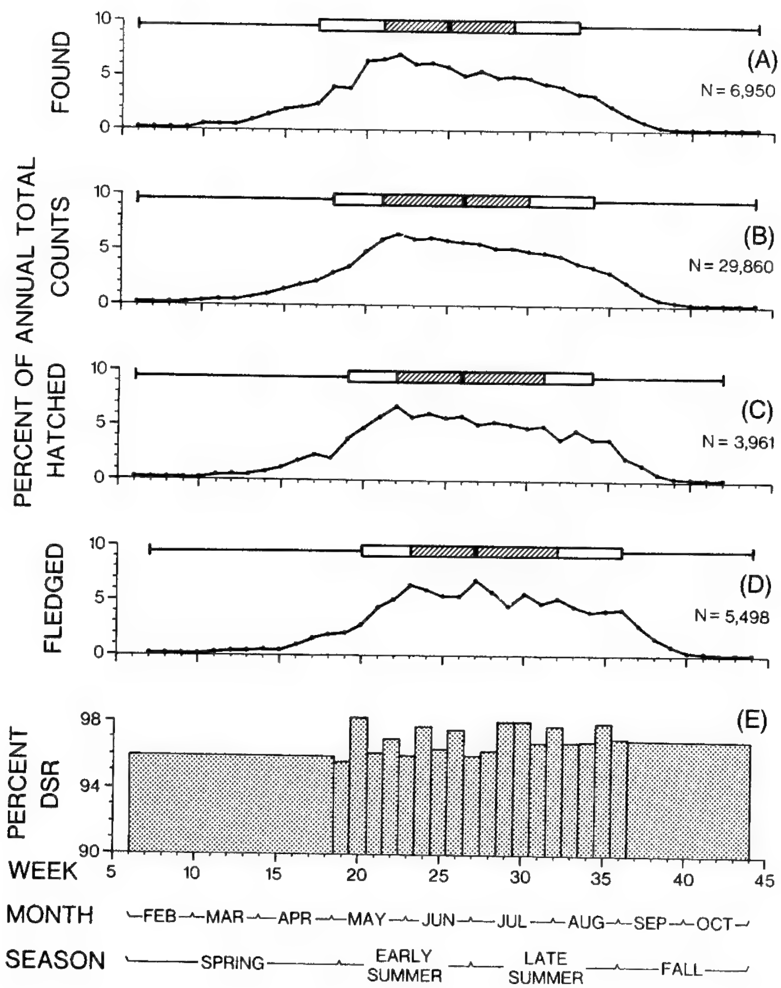


Fig. 7. Dove nesting variables from combined 1979 and 1980 data for the United States: (*A*) Nests first found each week; (*B*) Individual eggs and nestlings present each week; (*C*) Counts of nests with first egg hatched each week; (*D*) Fledged young recorded each week; (*E*) Daily survival rate of individual eggs and nestlings for each week. In the last graph, early and late weeks in the year are pooled for adequate sample size. Percentages in the first four graphs are based on annual totals. Endpoints of horizontal lines on the box plot represent maximum and minimum dates. The entire box plot shows 80% of the total, with the shaded area representing 50% of the total about the median.

seen in Fig. 5. Thus, the decline in numbers of fledged doves in September is due to a natural drop-off in nesting activity and not due to hunting disturbances.

Survival

Survival was estimated by daily survival rates of individual eggs and nestlings (Fig. 6; Table 6; Appendix E). Higher daily survival rates occurred in the northern parts of the EMU and CMU than in the southern parts ($P < 0.05$). The observed drop in survival rates for dove populations in fall in the WMU may result from the small sample of nests present in the management unit at that time.

National estimates of each of the variables discussed earlier show seasonal relations among the five measurements (Fig. 7). However, a national perspective may not be as useful for management of dove populations as the more detailed measurements at the management unit level.

Part II. Effects of September Hunting on Egg and Nestling Survival

The second objective of the present study was to determine if survival rates of mourning dove nests and of individual eggs and nestlings are lower in areas where early September dove hunting is permitted compared with nearby areas where it is prohibited.

Study Areas

Nesting data were collected on 11 paired study areas in 1978 and 1979 (Fig. 1; Appendix F). Each study area extended the entire length of a boundary that separated a "hunted zone" where September mourning dove hunting was allowed and a "nonhunted zone" where dove hunting either was prohibited or was delayed at least 21 days by State regulations (Fig. 8). In six of the study areas, State boundaries separated the hunted and nonhunted zones; the remaining five areas were within States where the hunted and nonhunted zones were separated by a zone boundary.

Each of the 11 study areas was divided into 12 strata of about equal size. Each stratum contained a pair of nest search plots which were located on a map by randomly selecting a point on the boundary line. The centers of the search plots were located at the end of a 16-km line perpendicular to the boundary in each direction from the random point. Nest search plots were circles with diameters of 3.2 km. In each stratum a primary and an alternate pair of nonoverlapping search plots were designated.

The stratification spread the sampling along the entire boundary between the hunted and nonhunted zones. The 16-km buffer between the center of the search plot and the boundary increased the probability that the daily movements of doves nesting in the plot would be confined to their respective zones. The paired search plots were used to reduce variability in habitat and weather and thus increase power of the tests. The random selection of search plots ensured that hunting in the sample plots in hunted sections was an unbiased sample of hunting activity that occurred along the boundary.

We assumed that the effects of hunting along the boundaries were similar to the effects of hunting elsewhere. The objective in this part of the study was to compare survival on areas open to hunting with survival on areas closed to hunting. It would have been impractical to relate specific levels of hunting with survival of doves. Therefore, no systematic measure was made during the study of actual hunting activities on the search plots.

Methods

Nest Observations

Nest searches took place in the paired search plots in each study area within the 10-day period immediately before the opening (as defined in the hunted zone) of the 1978 and 1979 mourning dove hunting season (Appendix F). If two nests could not be found in the primary search plot, the alternate was searched. About 84% of the nests were in primary plots. Observations of each nest began the day before the opening of the hunting season. Thereafter, nests were observed weekly either until the nest was destroyed or abandoned or until the 10th day after hatching. Whenever possible, each nest was visited on the 10th day after hatching because of our definition of fledging. In zoned States, the observation period ended when the delayed hunting season began in the nonhunted zone, even if observations on some nests were incomplete. For example, in Texas (1978), the obser-

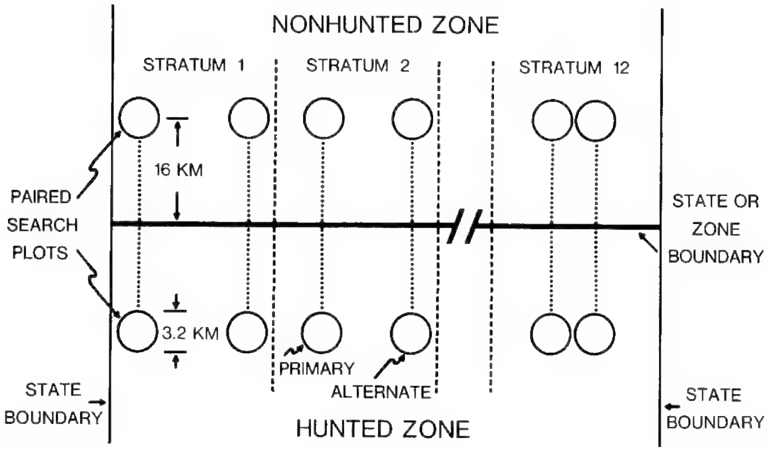


Fig. 8. Subdivisions of a study area and search plot locations for assessing the effects of hunting regulations.

vation period was from 1 September (opening of hunting in the hunted zone) until 22 September (day before the delayed opening of hunting in the nonhunted zone).

Analyses

The daily survival rate was estimated by using the procedure described in Part I. Data from the initially designated strata were combined into larger units with data from adjacent strata as necessary (Appendix G). In this way we increased the number of observed days above 20 days of exposure, assuring more stable estimates of daily survival.

We tested for differences in the daily survival rates between hunted and nonhunted zones by using two analyses of variance, a paired *t*-test, and a nonparametric sign test. In the parametric analyses, the error variance was calculated among groups of nests within the hunted or nonhunted zones of the strata. Thus it was not necessary to assume independence among the individual eggs or nestlings in a nest or among the days of exposure of a single nest. The analyses of variance probably provided the most powerful tests of our hypotheses. In order to maintain a reasonably large sample size for calculating stable daily survival rate estimates we conducted two analyses. One analysis maintained the sample size by pooling data for years and stages (egg and nestling: egg stage necessarily included some early nestlings; see Appendix A) and the other by pooling data for strata. Because no power analysis procedure is available for weighted analysis of variance, we also used a weighted paired *t*-test for which a power analysis was developed (Appendix H). The sign test was used because it does not require the distributional assumptions of the other tests.

The fledging rate for the entire nesting cycle based on the daily survival rate (DSR) is estimated by S^{26}, where S = DSR of eggs and nestlings, and 26 = number of days young doves must survive from egg laying to fledging. Fledging rates can be estimated for situations where adults are exposed to hunting for part of the nesting cycle by

$$F_d = S_h^d \, S_n^{26\text{-}d}$$

where F_d = fledging rate for eggs and nestlings exposed to effects of hunting for d days; S_h = postulated DSR when adults were exposed to hunting; S_n = postulated DSR when adults were not exposed to hunting; and d = number of days adults were exposed to hunting. The effect that a possible reduction in fledging rate due to hunting would have on the overall fledging rate can be estimated by

$$H \sum_{d=1}^{26} P_d \, (F_o - F_d)$$

where H = proportion of nesting in hunted States, based on call count surveys (Dolton 1982); P_d = proportion of eggs and nestlings exposed to effects of hunting for d days, based on hatch dates from the first objective; and $F_o - F_d$ = postulated difference between fledging rate without hunting (F_o) and fledging rate for eggs and nestlings exposed to effects of hunting for d days (F_d).

Table 7. *Numbers of mourning dove nests by study areas and years used in calculating daily survival rates for testing the effects of September hunting.*

Study area[a] H N	1978 H	1978 N	1979 H	1979 N	Both years H	Both years N
Paired States						
Illinois–Indiana	28	20	18	16	46	36
Kentucky–Indiana	18	25	13	38	31	63
Missouri–Iowa	8	24	11	22	19	46
Nebraska–Iowa	30	23	21	24	51	47
Nebraska–South Dakota	24	27	19	11	43	38
Pennsylvania–New Jersey	18	16	21	19	39	35
Zoned States						
Alabama	0	4	6	8	6	12
Georgia	7	10	17	15	24	25
Louisiana	8	7	10	6	18	13
Mississippi	7	3	5	3	12	6
Texas	11	16	17	14	28	30
Total	159	175	158	176	317	351
Total by year	334		334		668	

[a]H = hunted zones, N = nonhunted zone.

Nest survival rate was used to refer to the fate of all individual eggs and nestlings in a nest considered collectively. Two definitions of nest survival were used in addition to individual egg and nestling survival. In the first, a nest was recorded as lost when the first individual egg or nestling was lost (the "first lost" definition), whereas in the second, a nest was recorded as lost when all individuals were lost (the "all lost" definition). The all lost definition is more commonly used by wildlife biologists, but if the effect of hunting allows some parents to fledge one young but not more, the effect would be detected by using the first lost definition, but not the all lost definition of nest survival. Thus the first lost definition is more sensitive to the hypothesis tested than the second.

Table 8. *Number of eggs, nestlings, and nests present in hunted and nonhunted zones.*[a]

Treatment and year	Eggs	Nestlings	Nests	Individuals per nest
Hunted				
1978	199	112	159	1.956
1979	186	118	158	1.924
Subtotal	385	230	317	1.940
Nonhunted				
1978	225	113	175	1.931
1979	193	143	176	1.909
Subtotal	418	256	351	1.920
Total	803	486	668	1.930

[a]Number present either on the day before hunting began or on the first day the nest was observed after hunting began.

Table 9. *Survival estimates from hunted and nonhunted zones for individual eggs and nestlings and for nests.*

Study area	Individual survival: Egg–nestling			Nest survival: First lost[a]			All lost[b]		
	Days survived	Total days	DSR[c] (%)	Days survived	Total days	DSR[c] (%)	Days survived	Total days	DSR[c] (%)
Illinois–Indiana									
H[d]	667.5	695.5	96.0	345.5	362.5	95.3	368.5	382.5	96.3
N[d]	534.5	565.5	94.5	265.5	283.5	93.7	290.0	305.0	95.1
Kentucky–Indiana									
H	436.0	452.0	96.5	227.0	237.0	95.8	241.0	249.0	96.8
N	1,105.5	1,130.5	97.8	524.5	540.5	97.0	589.5	599.5	95.1
Missouri–Iowa									
H	259.0	275.0	94.2	120.5	130.5	92.3	139.5	146.5	95.2
N	663.5	699.5	94.9	314.5	336.5	93.5	378.5	394.5	95.9
Nebraska–Iowa									
H	968.5	1,004.5	96.4	483.0	503.0	96.0	503.0	521.0	96.5
N	951.5	976.5	97.4	495.5	509.5	97.3	513.5	526.5	97.5
Nebraska–South Dakota									
H	693.0	711.0	97.5	335.5	346.5	96.8	364.5	371.5	98.1
N	594.5	628.5	94.6	275.0	296.0	92.9	311.0	329.0	94.5
Pennsylvania–New Jersey									
H	612.0	642.0	95.3	300.0	316.0	94.9	318.0	332.0	95.8
N	592.5	615.5	96.3	304.0	317.0	95.9	316.5	327.5	96.6
Alabama									
H	112.0	114.0	98.2	56.0	57.0	98.2	56.0	57.0	98.2
N	226.0	232.0	97.4	109.0	113.0	96.5	120.0	123.0	97.6
Georgia									
H	234.0	265.0	88.3	117.0	134.0	87.3	121.0	137.0	88.3
N	359.0	389.0	92.3	167.5	184.5	90.8	197.0	212.0	92.9
Louisiana									
H	163.0	185.0	88.1	83.0	95.0	87.4	83.0	95.0	87.4
N	175.5	183.5	95.6	100.5	105.5	95.3	102.5	106.5	96.2
Mississippi									
H	169.5	184.5	91.9	79.5	87.5	90.9	99.0	105.0	94.3
N	98.0	98.0	100.0	49.0	49.0	100.0	49.0	49.0	100.0
Texas									
H	362.5	392.5	92.4	174.5	189.5	92.1	182.0	196.0	92.9
N	516.0	551.0	93.6	255.5	273.5	93.4	266.5	283.5	94.0
Combined estimate									
H	4,677.0	4,921.0	95.0	2,321.5	2,458.5	94.4	2,475.5	2,592.5	95.5
N	5,816.5	6,069.5	95.8	2,860.5	3,008.5	95.1	3,134.0	3,256.0	96.3
B[d]	10,493.5	10,990.5	95.5	5,182.0	5,467.0	94.8	5,609.5	5,848.5	95.9
Eggs and early nestling stage									
H	2,297.5	2,457.5	93.5	1,143.0	1,230.0	92.9	1,191.5	1,268.5	93.9
N	2,899.5	3,047.5	95.1	1,451.5	1,538.5	94.3	1,556.0	1,626.0	95.7
B	5,197.0	5,505.0	94.4	2,594.5	2,768.5	93.7	2,747.5	2,894.5	94.9
Later nestling stage									
H	2,379.5	2,463.5	96.6	1,178.5	1,228.5	95.9	1,284.0	1,324.0	97.0
N	2,917.0	3,022.0	96.5	1,409.0	1,470.0	95.9	1,578.0	1,630.0	96.8
B	5,296.5	5,485.5	96.6	2,587.5	2,698.5	95.9	2,862.0	2,954.0	96.9

[a]Nest recorded lost when first individual lost.
[b]Nest recorded lost when all individuals lost.
[c]DSR = Daily Survival Rate.
[d]H = hunted, N = nonhunted, B = both hunted and nonhunted.

Table 10. *Paired t-test of daily survival rates of eggs and nestlings in hunted and nonhunted zones. Years and stage (egg–nestling) are pooled (Appendix G). Strata within study areas remain separate. The angular transformation was used and the analysis was weighted by the number of days of exposure to stabilize the variance.*

Statistic	Individual survival: Egg–nestling	Nest survival: First lost[a]	Nest survival: All lost[b]
Paired t-statistic with 68 degrees of freedom	1.172	1.103	1.250
Probability level (one-tailed)[c]	0.123	0.137	0.108

[a]Nest recorded lost when first individual lost.
[b]Nest recorded lost when all individuals lost.
[c]Effects of hunting regulations are not significant ($P > 0.05$).

Results

Each year observers reported 334 nests; in both years combined there were 317 in hunted and 351 in nonhunted zones (Table 7). The total contained 803 eggs and 486 nestlings (Table 8); the percentages in the egg–early nestling stage were similar for hunted (62.6%) and nonhunted (62.0%) zones. Because the egg–early nestling stage had a lower survival rate than the nestling stage (Table 9), this small percentage difference tended to increase the apparent effect of hunting in any analysis ignoring nest stage.

Daily Survival Rates

The observed daily survival rates for each study area and for all areas combined are reported in Table 9, based on the number of nests reported in Table 7. (Data are available from Migratory Bird Research Branch, Patuxent Wildlife Research

Table 11. *Differences between daily survival rates in hunted and nonhunted zones that could be detected by the paired t-test with specified power.*[a]

Power[b]	Detectable daily survival rate under hunting with the daily mortality rate in parentheses: Individual survival: Egg–nestling	Nest survival: First lost[c]	Nest survival: All lost[d]
0.80	0.942 (0.058)	0.940 (0.060)	0.943 (0.057)
0.90	0.939 (0.061)	0.937 (0.063)	0.940 (0.060)
0.95	0.936 (0.064)	0.933 (0.067)	0.937 (0.063)
0.99	0.930 (0.070)	0.927 (0.073)	0.932 (0.068)
Daily survival rate with no hunting			
Hypothetical	0.960 (0.040)	0.960 (0.040)	0.960 (0.040)
Observed	0.958 (0.042)	0.951 (0.049)	0.963 (0.037)

[a]The size of the difference that could be reliably detected with a one-tailed paired t-test (Table 10) varies with the daily survival rate, although it is constant on the transformed scale in which the analysis was conducted. Rather than present the detectable difference on the angular transformed scale in terms of the arcsine of the square root of the daily survival rate, we have chosen to fix the nonhunting daily survival rate at a hypothetical 0.960 for the purpose of presenting detectable differences. Then we can express the detectable difference as the daily survival rate in the hunted zones which could be just detected with the specified power. The true value in the nonhunted zone is unknown, but for presentation purposes we have chosen a value and assumed that it is the true population value without error. This use of a single value for individual and nest survival rates allows one to compare the power of the analyses for the three survival rates. Proportional comparisons among values in the table may be misleading because they will change with the length of time the individual must survive.
[b]Probability of detecting differences.
[c]Nest recorded lost when first individual lost.
[d]Nest recorded lost when all individuals lost.

Center, U.S. Fish and Wildlife Service, Laurel, Maryland 20708.) Daily survival rates were lowest for the first lost definition of nest loss. This result would be expected because a nest with one surviving egg or nestling was counted as lost under this definition. With that definition the observed probability of nest survival in the combined hunted and nonhunted zones was 94.8%. Observed survival rates for individuals were slightly higher (95.5%). Observed nest survival was highest for the all lost definition (95.9%), where a nest with one surviving egg or nestling was considered successful.

The daily survival rates for individuals observed in the sample were 95.0% in the hunted zones and 95.8% in the nonhunted zones (Table 9). Based on the statistical tests, there is no evidence that this difference in the sample survival rate represents a real difference in the population survival rate.

Fledging Rates

Fledging rate is a biologically relevant restatement of daily survival rate because it measures survival throughout the nesting period from egg-laying to fledging. With 26 days as the period from egg-laying to fledging, the estimates for fledging rates in the hunted and nonhunted zones were 26% ($= 0.950^{26}$) and 33% ($= 0.958^{26}$), respectively. Because the fledging rates and daily survival rates are the same survival rates operating over different periods of time, the difference in the fledging rates, as with the daily survival rates, was not statistically significant.

Paired *t*-test

Results of the paired *t*-test indicated no significant difference in survival of individuals or nests between hunted and nonhunted zones of the study areas (Table 10; see further discussion in Appendix A). Because a difference was not detected, it is useful to estimate what size of a difference could have been detected by this test with a stated probability; this probability is called the power of the test (Cohen 1977; Appendix H).

By using a 5% significance level, a reduction in daily survival rate of individuals from a hypothetical value of 96.0% (35% for the fledging rate) under nonhunting conditions to 94.2% in daily survival rate (21% for the fledging rate) under hunting conditions could have been detected with 80% probability (Table 11). In power analyses, 80% is the power commonly used to specify an acceptable probability of detecting a stated difference.

If there was any undetected effect of hunting on the survival of eggs and nestlings, it would have only a small impact on the overall recruitment of fledged birds into the population. This is because only a small part of all nesting activity occurs after 1 September and few of those eggs and nestlings would be exposed to effects of hunting for the entire nesting cycle. The overall fledging rate would be reduced by about 0.4 percentage point if the observed differences in fledging rates between hunted and nonhunted zones were real. The reduction would be about 0.8 percentage point if larger differences in fledging rates (detectable with an 80% probability in our study) were true.

Analyses of Variance

The analyses of variance (Table 12) did not show a significant effect of hunting on either individual or nest survival. The stage difference (egg and early nestling versus nestling) was highly significant ($P < 0.01$) in both analyses; the nestling stage showed greater survival.

Sign Test

The sign test for the effect of hunting also did not reveal a significant difference for survival of individuals or nests between hunted and nonhunted zones (Table 13). Considering all strata within study areas for individual survival, 53% (36 strata) had higher daily survival rates in the hunted zones, whereas 47% (32 strata) had higher survival in the nonhunted zones.

Discussion

One objective of the annual establishment of the migratory bird hunting regulations is to limit harvest of migratory game birds to levels compatible with their ability to maintain their populations (U.S. Fish and Wildlife Service 1982). Regulations that permit the hunting of doves in September have been criticized because hunting concurrent with dove nesting activity was thought to interfere with the annual recruitment and maintenance of the population (McClure 1950; Schroeder 1970). An earlier U.S. Fish and Wildlife Service (1977) environmental

Table 12. *Analyses of variance of daily survival rates of eggs and nestlings in hunted and nonhunted zones.*[a] *Levels of significance:* * = *(0.1 > P > 0.05),* ** = *(0.05 > P > 0.01),* *** = *(0.01 > P > 0.001),* **** = *(0.001 > P), and* — = *(P > 0.10). Mean squares are given in Appendix I(7).*

Source	Degrees of freedom	Individual survival	Nest survival	
			First lost[b]	All lost[c]
Pooling years and stages; strata remain separate				
1 Study area	10			
2 Strata (within area)	58			
3 Hunted/nonhunted (H/N)[d]	1	—	—	—
4 Area × H/N	10	—	—	—
5 Strata × H/N (within area)	58			
Pooling strata; years and stages remain separate				
1 Study area	13			
2 Hunted/nonhunted (H/N)	1	—	—	—
3 Area × H/N	13			
4 Stage	1	***	***	***
5 Area × stage	13			
6 H/N × stage	1	—	—	*
7 Area × H/N × stage	13			
8 Year	1	—	—	—
9 Area × year	13			
10 H/N × year	1	—	—	—
11 Area × H/N × year	13			
12 Year × stage	1	*	*	*
13 Area × year × stage	13			
14 H/N × year × stage	1	—	—	—
15 H/N × year × stage × area	13			

[a]The angular transformation was used to stabilize the variance, and the analysis was weighted by the number of egg and nestling days observed for individual survival and by nest days for nest survival. *Areas, strata,* and *years* were considered random effects. Other effects were considered fixed. Probabilities for treatment represents one-tailed tests.
[b]Nest recorded lost when first individual lost.
[c]Nest recorded lost when all individuals lost.
[d]Effect of hunting regulations was not significant ($P > 0.05$).
Two-tailed probabilities from the F distribution have been divided by 2 to obtain the indicated one-tailed probabilities.

Table 13. *Sign test of daily survival rates of eggs and nestlings in hunted and nonhunted zones, combining stages and years.*

No. of strata with higher daily survival rate	Individual survival	Nest survival	
	Egg–nestling	First lost[a]	All lost[b]
Hunted zones	36	34	30
Nonhunted zones	32	34	34
Probability level for sign test (one-tailed)[c]	0.358	0.548	0.734

[a]Nest recorded lost when first individual lost.
[b]Nest recorded lost when all individuals lost.
[c]Not significant ($P > 0.05$).

assessment concluded that September dove hunting had negligible impact on the maintenance of dove populations. The present study was initiated to examine in more detail the effects of September hunting on the survival of dove eggs and nestlings. In this study we considered the proportion of all dove nesting effort throughout a year that was potentially exposed to hunting, and the effect of hunting on survival of those eggs and nestlings that were produced in September. In addition our study provides information concerning possible effects of hunting on the length of the nesting season.

Exposure to Hunting

Late Season Nest Initiation

Nationwide nest initiation, based on weekly number of nests first found, reached its highest peak in late May (week 22) with a midpoint of activity in mid-June (week 25, Fig. 7). By early August (week 33), 90% of all nest initiation had occurred (Fig. 7). For each of the management units, more than 90% of total nest initiation had occurred by mid-August (week 34, Fig. 2). Nationally, 2.7% of all nesting attempts were initiated in September and October. If we use the estimate based on backdating from hatch dates, only 1.0% of nest initiation occurred in September and October.

Other investigators have also reported reductions in nest initiation late in the nesting season. Hanson and Kossack (1963) found that 5% of the nests were initiated after mid-July in Illinois. In Georgia, 5.6% of all nesting began after August (G. H. Haas, unpublished report). Soileau (1960) reported a 3-year average of 8.6% of nest attempts in September for Louisiana; his review of seven other States showed less than 10% of total active nests occurring in September.

Late Season Nesting Activity

We found a decline in nesting activity in the latter part of the nesting season. The weekly proportion of the annual total of counts of individual eggs or nestlings nationwide reached a peak in late May (week 22) and a midpoint by late June (week 26, Fig. 7). By mid-August (week 34), 90% of the weekly counts of dove eggs and nestlings had been recorded. Only 4.5% of all weekly counts of individual eggs or nestlings occurred in September and October.

In an earlier review of the literature, 5.6% of all nests nationwide were active after 1 September (U.S. Fish and Wildlife Service 1977). Other investigators have reported reductions in nesting activity by 1 September in North Dakota (Bolt and Hendrickson 1952), California (Cowan 1952), Minnesota (Harris et al. 1963), and Kansas (Schroeder 1970).

Late Season Fledging

The peak and midpoint of dove fledging occurred by the last week in June (week 27, Fig. 7). Nationally, 10.3% of the fledgings of nestlings were in September and October. If we estimate fledging by extending hatching dates 12 days to allow for the nestling stage, we obtain a very similar estimate of 90% of nests nationwide that were completed by 4 September.

In an earlier review of the literature, a similar average of 9.6% of fledging occurred after 1 September (U.S. Fish and Wildlife Service 1977). Reductions in fledging rates during the last weeks of the nesting season have been reported for several States. In Illinois, 2% of the fledged doves came from nests initiated after 5 August (Hanson and Kossack 1963). Schnoes (1980) reported that 5% of all fledging occurred after 30 August in Florida. In Minnesota (Harris et al. 1963), and Iowa and Nebraska (McClure 1950), more than 16% of the dove fledging was after 1 September. These percentages for the three Midwestern States are higher than the 9.2–12.9% confidence interval reported in our study for the CMU-N.

Effects of September Hunting on Survival of Eggs and Nestlings

We examined the effects of September hunting on daily survival rates of individual eggs and nestlings. No statistically significant difference was found between the hunted and nonhunted zones (95.0% and 95.8%, respectively; Table 9). The fledging rates for hunted and nonhunted zones (26% and 33%, respectively) are the same rates as the daily survival rates operating over a longer period of exposure. Thus we have no evidence that the fledging rates reflect a real population difference, based on statistical tests. The power analysis for our statistical test indicated that we had an 80% probability of detecting any real effect of hunting that was greater than a reduction

from a hypothetical 96.0% daily survival rate to 94.2% (from 35 to 20% fledging rates, Table 11). An undetected reduction in fledging rate of that magnitude would probably reduce the overall fledging rate by less than 1 percentage point, because only a small proportion of the nesting doves are exposed to hunting for the full 26-day nesting cycle.

A few other studies have analyzed the effects of hunting on dove production. Winston (1953) concluded that hunting had no effect on the species and suggested the season could be lengthened, although he offered few data to support his view. In the EMU, no effect of changing bag limits from 12 to 18 doves could be detected for any of several measurements except daily bag (Hayne 1975). G. H. Haas (unpublished report), who studied 52 radio-tagged breeding pairs of doves nesting after 1 September in Georgia during 1979–80, found that the loss in potential annual recruitment due to hunting was less than 1%; this reflects a 7.7% loss of nests in September due to hunting.

Several studies relate indirectly to effects of hunting on dove production. Behavioral differences between nesting and non-nesting doves may affect hunting vulnerability; nesting doves tend to feed separately, making them less likely targets than the flocks of non-nesting adults and juveniles (Southeastern Association of Game and Fish Commissioners 1957). Studies simulating the loss of a parent to hunting have shown that nestlings have a lower chance of survival when raised by only one parent. Success in raising two nestlings is improved if the young birds are 6–8 days old before one parent is lost (Laub 1956; Bivings 1980; Haas 1980). In captive doves, if both parents are lost, 72% of 9- to 17-day-old fledglings will survive (Mirarchi and Scanlon 1981).

Effects of Hunting on Length of Nesting Season

It is important to consider the possible effects of hunting on the length of the annual nesting season. If hunting disturbance had reduced the nesting activity on our study areas, we would have underestimated the potential amount of nesting activity in September and October in hunted areas. We used the number of new nests found as an indicator of trends in later production. By comparing Figs. 2 and 5, one can see that the decline in nestlings fledged after the first week in September (week 36) for the CMU-N, for example, was preceded by a parallel decline in nests first found for the CMU-N after mid-August (week 34). The weekly distribution of fledged young (Fig. 5) closely follows the distribution of nests found (Fig. 2) with about a 3-week lag. The nesting cycle lasts about 3.5 weeks and, because we do not know the exact date for any nest, we assume that on the average all were found a half week after they were initiated. From these results, we may conclude that there is a natural decline in nesting activity that occurred independent of, and before, the onset of the hunting season on or after 1 September.

McClure (1950) compared large numbers of nests in two nonhunting States (Iowa and Nebraska) with those in a hunting State (California). Nesting began and ended sooner in California than in the two Central States. He concluded that the nesting season in California was curtailed because of disruption from hunting. Our results also showed that the nesting season ended earlier in the WMU compared with the CMU-N ($P < 0.01$; Fig. 4). However, the reduction in nest initiation (Figs. 2 and 4) for both management units, especially the WMU, began before the first week in September (week 36). These results suggest that the difference in the decline of nesting activity between the management units is a natural phenomenon and is not caused by hunting disturbance.

Conclusions

From the first part of the study we found that, depending on the measure, 1% or 3% of all nesting attempts occurred when adult doves were potentially exposed to hunting for the complete nesting cycle. Ten percent of the fledglings had all or part of their nesting period after 1 September. Extrapolation of these estimates to a national level causes the exposure to hunting to be overestimated because some doves nest in areas where hunting is not permitted.

From the second part of the study, we were unable to detect any effect of September hunting on survival of eggs and nestlings. Results of the power analysis assured us that with 80% probability we would have been able to detect a reduction in daily survival rate greater than 96.0 to 94.2% (or 35 to 21% in fledging rates). An undetected reduction in fledging rate of that magnitude would probably reduce the overall fledging rate by less than 1 percentage point, because only a small proportion of the

nesting doves are exposed to hunting for the full 26-day nesting cycle. Because the number of nests first found decreased before the start of hunting on 1 September, we concluded that the reduction in nest activity at the end of the season is a natural phenomenon and not caused by hunting disturbance.

These results indicate that it is unlikely that current dove hunting regulations, which allow hunting to start on 1 September, have a significant effect on recruitment of fledglings into the dove population.

Acknowledgments

We gratefully acknowledge the cooperation of all State, Federal, and university administrators, biologists, and technicians, including personnel from the Animal Damage Control Program (Fish and Wildlife Service), wildlife refuge personnel, Young Adult Conservation Corps (YACC) members, Comprehensive Employment Training Administration (CETA) personnel, and volunteers from nature centers in Bucks County, Pennsylvania. The project would not have been possible without their input and cooperation.

F. W. Martin and J. P. Rogers were helpful in developing and planning the study and offered timely advice and overall direction. R. S. Pospahala was instrumental in the initial organization and coordination of the work.

Computer and statistical assistance were provided by L. M. Moyer. S. L. Stokes developed the power analysis for the paired *t*-test. D. M. Detwiler, R. C. Perry, and B. H. Galowin provided clerical and editorial assistance.

We also thank those people who reviewed the manuscript and offered suggestions: I. J. Ball, G. K. Brakhage, T. J. Dwyer, G. H. Haas, G. M. Haramis, D. H. Johnson, F. W. Martin, J. D. Nichols, R. S. Pospahala, H. M. Reeves, J. L. Ruos, R. E. Tomlinson, B. K. Williams, and V. L. Wright (Louisiana State University).

Individuals acknowledged are, or were, Fish and Wildlife Service employees unless otherwise indicated.

References

Aldrich, J. W., and A. J. Duvall. 1958. Distribution and migration of races of the mourning dove. Condor 60:108–128.

Bivings, A. E., IV. 1980. Breeding ecology of the mourning dove on the Texas A&M University campus. Ph.D. thesis, Texas A&M University, College Station. 55 pp.

Bolt, W., and G. O. Hendrickson. 1952. Mourning dove production in North Dakota shelterbelts, 1950. J. Wildl. Manage. 16:187–191.

Burch, M. S. 1982. Nesting ecology in mourning doves in Knox and Loudon counties, Tennessee. M.S. thesis, University of Tennessee, Knoxville. 83 pp.

Cohen, J. 1977. Statistical power analysis for the behavioral sciences. Academic Press Inc., New York. 474 pp.

Cowan, J. B. 1952. Life history and productivity of a population of western mourning doves in California. Calif. Fish Game 38(4):505–521.

Dolton, D. D. 1980. Mourning dove breeding population status. Administrative report. U.S. Fish and Wildlife Service, Washington, D.C. 25 pp.

Dolton, D. D. 1982. Mourning dove breeding population status. Administrative report. U.S. Fish and Wildlife Service, Washington, D.C. 19 pp.

Dunks, J. H. 1977. Texas mourning dove band recovery analysis, 1967–1974. Texas Parks and Wildlife Department. Fed. Aid Rep. Ser. 14. 94 pp.

Dunks, J. H., R. E. Tomlinson, H. M. Reeves, D. D. Dolton, C. E. Braun, and T. P. Zapatka. 1982. Mourning dove banding analysis, Central Management Unit, 1967–77. U.S. Fish Wildl. Serv., Spec. Sci. Rep.—Wildl. 249. 128 pp.

Haas, G. H. 1980. Success of single-parent mourning doves. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 34:426–429.

Hanson, H. C., and C. W. Kossack. 1963. The mourning dove in Illinois. Southern Illinois University Press, Carbondale. 133 pp.

Harris, S. W., M. A. Morse, and W. H. Longley. 1963. Nesting and production of the mourning dove in Minnesota. Am. Midl. Nat. 69:150–172.

Hayne, D. W. 1975. Experimental increase of mourning dove bag limit in Eastern Management Unit. Southeast. Assoc. Game Fish Comm. Tech. Bull. 2. 56 pp.

Hensler, G. L., and J. D. Nichols. 1981. The Mayfield method of estimating nest success: a model, estimators and simulation results. Wilson Bull. 93:42–53.

Hollander, M., and D. A. Wolfe. 1973. Nonparametric statistical methods. John Wiley & Sons, Inc., New York. 503 pp.

Hughes, J. L. 1981. A mourning dove nesting study in Baton Rouge, Louisiana, with special reference to the importance of late season nesting. M.S. thesis, Louisiana State University, Baton Rouge. 90 pp.

Johnson, D. H. 1979. Estimating nest success: the Mayfield method and an alternative. Auk 96:651–661.

Keeler, J. E., chairman. 1977. Mourning dove (*Zenaida macroura*). Pages 275–298 *in* G. C. Sanderson, ed. Management of migratory shore and upland game birds in North America. University of Nebraska Press, Lincoln.

Laub, K. W. 1956. The relation of parental care and the condition of the glandular crop to the successful rearing of young mourning doves, *Zenaidura macroura* (L.). M.S. thesis, Ohio State University, Columbus. 68 pp.

Marion, W. R., and M. S. Schnoes. 1982. Seasonality of mourning dove nesting in Florida. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 36:543–551.

Mayfield, A. 1961. Nesting success calculated from exposure. Wilson Bull. 73:255–261.
Mayfield, A. 1975. Suggestions for calculating nest success. Wilson Bull. 87:456–466.
McClure, H. E. 1950. An 11-year summary of mourning dove observations in the West. Trans. N. Am. Wildl. Conf. 15:335–343.
Miller, H. W., and D. H. Johnson. 1978. Interpreting the results of nesting studies. J. Wildl. Manage. 42:471–476.
Mirarchi, R. E., and K. Hudson. 1981. Late season production of mourning doves in Alabama. Highlights Agric. Res. Agric. Exp. Stn. (Auburn, Ala.) 28(3):10.
Mirarchi, R. E., and P. F. Scanlon. 1981. Effects of orphaning on captive fledgling mourning doves. J. Wildl. Manage. 45:218–222.
Pearce, D. J. 1981. Mourning dove recruitment in Mississippi. M.S. thesis, Mississippi State University, Mississippi State. 27 pp.
Ray, A. A., editor. 1982. SAS users guide: statistics. SAS Institute Inc. Cary, N.C. 584 pp.
Robbins, C. S., and W. T. Van Velzen. 1969. The breeding bird survey, 1967 and 1968. U.S. Fish Wildl. Serv., Spec. Sci. Rep.—Wildl. 124. 107 pp.
Schnoes, M. S. 1980. The importance of fall nesting of mourning doves (*Zenaida macroura*) in Florida. M.S. thesis, University of Florida, Gainesville. 56 pp.
Schroeder, M. H. 1970. Mourning dove production in a Kansas osage orange planting. J. Wildl. Manage. 34:344–348.
Snedecor, G. W., and W. G. Cochran. 1980. Statistical methods. Iowa State University Press, Ames. 507 pp.
Soileau, L. D. 1960. Eastern mourning dove production in Roselawn Cemetery, Baton Rouge, Louisiana. M.S. thesis, Louisiana State University and Agricultural and Mechanical College, Baton Rouge. 38 pp.
Southeastern Association of Game and Fish Commissioners. 1957. Mourning dove investigations, 1948–56. Southeast Assoc. Game Fish Comm. Tech. Bull. 1. 166 pp.
U.S. Fish and Wildlife Service. 1975. Issuance of annual regulations permitting the sport hunting of migratory birds. Final environmental statement, Department of the Interior, Washington, D.C. 710 pp.
U.S. Fish and Wildlife Service. 1977. Proposal for continuation of September hunting of mourning doves. Department of the Interior, Washington, D.C. 42 pp.
U.S. Fish and Wildlife Service. 1982. Proposed 1982–83 migratory game bird hunting regulations (preliminary). Fed. Regist. 47:16718–16731.
Winston, F. A. 1953. The effect of hunting on the dove population. Proc. Southeast. Assoc. Game Fish Comm. 7:87–97.

APPENDIX A

Statistical Methods for Survival Analyses.

Daily Survival Rate

Date of laying or hatching was defined as the day on which the event occurred for the first egg or nestling, in nests where more than one were present and an age difference was detectable. Usually hatching occurred about the 14th day after laying. If an egg failed to hatch in 16 days, it was considered infertile and was recorded as surviving to the 14th day. If an egg did not hatch within two days after the last egg hatched, it was considered infertile and was recorded as surviving up to the date that the last egg hatched.

Daily survival rates are useful in estimating survival over a particular period in the nesting cycle or for the entire period. For example, one estimate of survival over the entire 26-day nesting period (14 days in egg stage, and 12 days in nestling stage) is:

$$\begin{bmatrix}\text{daily survival rate}\\ \text{for egg stage}\end{bmatrix}^{14} \begin{bmatrix}\text{daily survival rate}\\ \text{for nestling stage}\end{bmatrix}^{12} = 26 \text{ day survival rate}$$

or, using only the overall daily survival rate, $(\text{daily survival rate})^{26}$ = 26 day survival rate. This rate represents the estimated proportion expected to survive from the first day of incubation to the day of fledging.

An advantage of the daily survival rate method is that it takes into consideration the time span over which nests are observed, by considering the number of days survived. This method accounts for the increased probability that fledging will occur with each additional day after nest initiation. The conventional method of dividing number of individuals fledged by the number present when the nests were found overestimates fledging success because it does not consider age of the nests. Two additional advantages are gained in the use of the daily survival rate method. First, it has less variability leading to a more powerful test for the same sample size, due to the allowance for the age differences in nests. Second, the daily survival rate method allows the use of survival and loss days for each individual as long as the nest was observed for a minimum of two days, even if the nest is not visited on the day before the hunting season starts, or on the 10th day after hatching (definition of fledging). Therefore, a larger amount of the nest data can be used, giving a larger sample size for a given amount of effort compared with the conventional method.

Daily survival rates were calculated separately for eggs and nestlings to determine if differences were detectable. When a nest that previously contained eggs was found empty or destroyed, it was often impossible to determine if the eggs had hatched before the loss. For this reason, the egg stage necessarily included early nestling stage. We defined egg stage as the period from first visit when eggs were present to the first visit when nestlings were present.

Use of the daily survival rate method calls for a summation of days survived and total days lost. Days survived were summed beginning with the first day of hunting for the second part of the study. Nests were not visited daily during incubation and early brooding, so the specific day on which a loss occurred usually could not be determined. In these instances survival was considered to terminate at the midpoint of the interval between nest visits. The interval is the number of days between visits minus 1 day loss for each individual. When an individual was lost, one day of loss was counted. As an example, a successful two-egg nest observed from laying through 10 days after hatching represents a maximum of 24 days (14 days incubation plus 10 days as a nestling) for each individual, or a total of 48 egg and nestling days. If, in the example, a loss of both eggs was observed on the 10th day of incubation, and if the nest was known to be active on day 9, 9 days would be counted as survived and one day as lost for each egg. The daily survival rate in this instance would be 9/(9 + 1) or 0.90 for each egg (days survived/total exposure, where total exposure is days survived plus days lost).

If the nest was visited on day 10 and found to have been destroyed, but last visited and active on day 5, the days survived for each individual is unknown but could have been 5, 6, 7, 8, or 9 days. We used the mean of these possible values (7). The daily survival rate for both individuals is (total survival days)/(survival days plus loss days), or 14/(14 + 2) = 0.88.

Nest survival was calculated in the same manner. We defined nest loss two ways: (1) lost when the first individual (egg or nestling) was lost, and (2) lost only when all individuals were lost. These two definitions were used to allow for the possibility that hunting may decrease the probability of parents fledging one young but not all. Thus, three sets of daily survival rates were calculated and analyzed in the same manner.

A critical point is to count only those survival days for which a loss could also have been observed. For this reason, it was important to determine the status of each nest used for part II on the day before hunting began in each study area to assure that only nests active when hunting began were considered in the sample. A loss could be accurately attributed to a date after the hunting season opened only for nests visited and known to be active on the last day before hunting began. Likewise, the use of the observation on the 10th day rather than a later day after hatching greatly reduced the possibility of recording an empty nest as a loss when it may have fledged.

The paired *t*-test (Table 10) examines the differences between the daily survival rates in the hunted and nonhunted zones of the strata. Years and stages were pooled for this test to increase its power by maximizing the number of independent pairs. To equalize the variance, the test statistic was weighted to allow for the widely differing numbers of observation days in each zone of each stratum, and the angular transformation was used (Snedecor and Cochran 1980: 290).

Analysis

For the analysis of variance tests in the second part, the independent experimental units were the hunted and nonhunted zones of the strata within each study area. Thus, it was not necessary to assume independence between individuals in the same nest, or among the days of observations on an individual egg or nestling, or among nests in the same zone of a stratum. With these experimental units, the statistical tests used the consistency of the differences in daily survival rates between hunted and nonhunted zones over all the strata to determine significance.

Two analyses of variance were conducted. The first pooled years and stages (eggs and nestlings), keeping strata separate (Table 12), whereas the

second pooled strata, keeping years and stages separate (Table 12). The first allows greater geographic stratification and the second allows the testing of stage effects. Daily survival rates of individuals and nests were analyzed separately with both analyses of variance. The analyses were weighted by the number of egg and nestling days or nest days observed in each zone of each stratum to allow for the widely differing numbers of observation days in each. The arcsin transformation was used to stabilize the variance (Snedecor and Cochran 1980: 290). Study areas were considered to be random effects rather than fixed for the analyses, because inferences were to be made about a hypothetical population of similar areas rather than confined to the study areas chosen. Strata were also considered to be random effects; other effects were considered fixed.

A sign test was also used to test the hypothesis of no difference between the daily survival rates in the treatment and control zones of each stratum (Hollander and Wolfe 1973: 39-45). This nonparametric test requires fewer assumptions than other analyses.

Interpretation of Results

The one-tailed paired t-test showed that the effect of hunting was not significant ($p > 0.05$; Table 10). The important question then became how large a real difference might exist without being detected by this test. The size of this difference varies with the daily survival rate, although it is constant on the transformed scale in which the analysis was conducted. Rather than presenting the detectable difference in the angular transformed scale in terms of the arcsin of the square root of the daily survival rate, we have chosen to fix one rate at a hypothetical value (0.960 for the nonhunting daily survival rate). The second rate was then calculated to illustrate the detectable difference. The true daily survival rates are unknown. The same hypothetical nonhunting survival rate was used for individual survival and the two definitions of nest survival. This allows one to compare the power of the three analyses.

We express the detectable difference as the daily survival rate in the hunted zones for which a difference below the hypothetical rate in nonhunted zones (0.960) could be just detected with a specified power (Table 11). This power is the probability of detecting a difference when a true difference of a specified size exists. When a test does not show a significant difference, the power analysis provides assurance that if a real difference exists, it is probably less than the stated value.

To interpret the detectable differences, consider the individual daily survival rate and a power of 0.80 (Table 11). With the hypothetical nonhunting survival rate fixed at 0.960, we would be able to detect the difference with power (probability) 0.80, if the true daily survival rate were 0.942 in the hunting zone. This difference may be expressed as daily mortality rates (one minus the daily survival rates) of 0.040 for the nonhunting zones compared with 0.058 for the hunting zones. It may also be expressed as a 26-day survival rate (fledging rate) of $(0.960)^{26} = 0.346$ for nonhunting zones compared with $(0.942)^{26} = 0.212$ for hunting zones. Proportional comparisons between the hunting and nonhunting rates in Table 11 may be misleading because they will change with the length of time the individual must survive and with the consideration of survival or mortality rates. For example, the proportional relationships vary among daily survival rates (0.960, 0.942), daily mortality rates (0.040, 0.058), and fledging rates (0.346, 0.212).

APPENDIX B

Numbers of Dove Nests Used in Analysis of Seasonal Patterns of Nesting.

Management unit division	State	Year	Nests used	Management unit division	State	Year	Nests used
US	All	All	6950	EMU-S	SC	All	105
US	All	79	3307	EMU-S	SC	79	41
US	All	80	3643	EMU-S	SC	80	64
				EMU-S	TN	All	87
EMU-N	All	All	731	EMU-S	TN	79	35
EMU-N	All	79	297	EMU-S	TN	80	52
EMU-N	All	80	434				
EMU-N	IL	All	47	CMU-N	All	All	2898
EMU-N	IL	79	27	CMU-N	All	79	1388
EMU-N	IL	80	20	CMU-N	All	80	1510
EMU-N	IN	All	19	CMU-N	CO	All	277
EMU-N	IN	79	5	CMU-N	CO	79	76
EMU-N	IN	80	14	CMU-N	CO	80	201
EMU-N	KY	All	198	CMU-N	IA	All	1141
EMU-N	KY	79	84	CMU-N	IA	79	452
EMU-N	KY	80	114	CMU-N	IA	80	689
EMU-N	MD	All	340	CMU-N	ND	All	707
EMU-N	MD	79	110	CMU-N	ND	79	422
EMU-N	MD	80	230	CMU-N	ND	80	285
EMU-N	OH	All	1	CMU-N	NE	All	598
EMU-N	OH	79	1	CMU-N	NE	79	351
EMU-N	PA	All	70	CMU-N	NE	80	247
EMU-N	PA	79	29	CMU-N	SD	All	175
EMU-N	PA	80	41	CMU-N	SD	79	87
EMU-N	VA	All	51	CMU-N	SD	80	88
EMU-N	VA	79	41				
EMU-N	VA	80	10	CMU-S	All	All	1184
EMU-N	WV	All	5	CMU-S	All	79	639
EMU-N	WV	80	5	CMU-S	All	80	545
				CMU-S	MO	All	106
EMU-S	All	All	1146	CMU-S	MO	79	80
EMU-S	All	79	497	CMU-S	MO	80	26
EMU-S	All	80	649	CMU-S	NM	All	218
EMU-S	AL	All	137	CMU-S	NM	79	93
EMU-S	AL	79	71	CMU-S	NM	80	125
EMU-S	AL	80	66	CMU-S	OK	All	416
EMU-S	FL	All	319	CMU-S	OK	79	233
EMU-S	FL	79	165	CMU-S	OK	80	183
EMU-S	FL	80	154	CMU-S	TX	All	444
EMU-S	GA	All	115	CMU-S	TX	79	233
EMU-S	GA	79	62	CMU-S	TX	80	211
EMU-S	GA	80	53				
EMU-S	LA	All	173	WMU	All	All	991
EMU-S	LA	79	68	WMU	All	79	486
EMU-S	LA	80	105	WMU	All	80	505
EMU-S	MS	All	116	WMU	CA	All	722
EMU-S	MS	79	33	WMU	CA	79	392
EMU-S	MS	80	83	WMU	CA	80	330
EMU-S	NC	All	94	WMU	UT	All	269
EMU-S	NC	79	22	WMU	UT	79	94
EMU-S	NC	80	72	WMU	UT	80	175

APPENDIX C

Numbers of Nests First Found, Individual Eggs and Nestlings Present in All Nests, and Doves Fledged Each Week.

Management unit division	Week	Month	Nests found	Eggs and nestlings present	Doves fledged
US	All	All	6950	29860	5498.0
US	6	Feb	5	10	0.0
US	7	Feb	0	8	3.4
US	8	Feb	10	19	2.0
US	9	Feb	10	28	2.0
US	10	Mar	33	90	0.0
US	11	Mar	30	115	14.3
US	12	Mar	29	123	21.8
US	13	Mar	66	180	24.5
US	14	Apr	100	285	28.1
US	15	Apr	127	411	25.2
US	16	Apr	141	532	55.3
US	17	Apr	163	623	83.5
US	18	Apr	272	873	107.0
US	19	May	266	1023	112.6
US	20	May	435	1431	154.9
US	21	May	448	1765	243.7
US	22	May	480	1918	283.9
US	23	Jun	416	1795	353.6
US	24	Jun	427	1834	329.6
US	25	Jun	398	1757	299.5
US	26	Jun	343	1694	298.7
US	27	Jul	374	1671	371.4
US	28	Jul	329	1528	320.9
US	29	Jul	343	1510	244.9
US	30	Jul	330	1475	311.2
US	31	Jul	299	1401	261.4
US	32	Aug	278	1354	293.1
US	33	Aug	229	1133	247.1
US	34	Aug	219	1045	217.1
US	35	Aug	161	885	223.4
US	36	Sep	95	640	233.6
US	37	Sep	57	367	153.8
US	38	Sep	22	188	89.6
US	39	Sep	9	91	51.1
US	40	Oct	2	32	15.0
US	41	Oct	3	16	14.1
US	42	Oct	1	8	2.0
US	43	Oct	0	2	2.7
US	44	Oct	0	0	2.0
EMU-N	All	All	731	3424	744.9
EMU-N	11	Mar	1	2	0.0
EMU-N	12	Mar	1	4	0.0
EMU-N	13	Mar	21	37	0.0
EMU-N	14	Apr	35	88	3.9
EMU-N	15	Apr	41	138	3.9
EMU-N	16	Apr	51	193	21.7
EMU-N	17	Apr	46	215	23.5
EMU-N	18	Apr	37	198	46.3
EMU-N	19	May	41	202	38.0
EMU-N	20	May	40	181	47.2
EMU-N	21	May	28	166	35.0
EMU-N	22	May	25	144	37.4
EMU-N	23	Jun	23	128	51.1
EMU-N	24	Jun	22	94	21.4
EMU-N	25	Jun	39	140	24.6
EMU-N	26	Jun	30	145	24.9
EMU-N	27	Jul	26	145	33.5
EMU-N	28	Jul	21	120	42.7

APPENDIX C Continued.

Management unit division	Week	Month	Nests found	Eggs and nestlings present	Doves fledged
EMU-N	29	Jul	26	102	25.0
EMU-N	30	Jul	27	118	30.3
EMU-N	31	Jul	25	125	16.1
EMU-N	32	Aug	29	130	38.1
EMU-N	33	Aug	24	128	39.3
EMU-N	34	Aug	25	114	14.2
EMU-N	35	Aug	18	115	26.7
EMU-N	36	Sep	10	88	36.9
EMU-N	37	Sep	9	62	20.1
EMU-N	38	Sep	8	51	14.8
EMU-N	39	Sep	1	36	15.8
EMU-N	40	Oct	0	11	4.9
EMU-N	41	Oct	1	2	5.6
EMU-N	42	Oct	0	2	2.0
EMU-S	All	All	1146	4556	848.9
EMU-S	6	Feb	5	10	0.0
EMU-S	7	Feb	0	8	3.4
EMU-S	8	Feb	10	19	2.0
EMU-S	9	Feb	10	28	2.0
EMU-S	10	Mar	33	90	0.0
EMU-S	11	Mar	25	107	14.3
EMU-S	12	Mar	20	101	21.8
EMU-S	13	Mar	36	115	20.8
EMU-S	14	Apr	52	155	18.9
EMU-S	15	Apr	49	184	15.4
EMU-S	16	Apr	45	192	29.2
EMU-S	17	Apr	48	179	44.1
EMU-S	18	Apr	48	189	34.1
EMU-S	19	May	46	161	29.2
EMU-S	20	May	40	180	28.9
EMU-S	21	May	46	187	38.0
EMU-S	22	May	57	209	26.2
EMU-S	23	Jun	42	177	44.8
EMU-S	24	Jun	59	209	31.0
EMU-S	25	Jun	52	203	33.0
EMU-S	26	Jun	41	182	29.0
EMU-S	27	Jul	55	214	38.0
EMU-S	28	Jul	40	182	28.2
EMU-S	29	Jul	29	156	29.4
EMU-S	30	Jul	46	154	45.3
EMU-S	31	Jul	49	170	23.4
EMU-S	32	Aug	34	163	29.3
EMU-S	33	Aug	27	141	28.2
EMU-S	34	Aug	27	120	33.6
EMU-S	35	Aug	20	93	30.1
EMU-S	36	Sep	24	99	25.1
EMU-S	37	Sep	17	73	19.5
EMU-S	38	Sep	2	48	20.6
EMU-S	39	Sep	7	29	14.4
EMU-S	40	Oct	2	11	8.2
EMU-S	41	Oct	2	10	4.8
EMU-S	42	Oct	1	6	0.0
EMU-S	43	Oct	0	2	2.7
EMU-S	44	Oct	0	0	2.0
CMU-N	All	All	2898	12644	2346.1
CMU-N	14	Apr	1	1	0.0
CMU-N	15	Apr	1	4	0.0
CMU-N	16	Apr	6	13	0.0
CMU-N	17	Apr	21	51	0.0
CMU-N	18	Apr	104	231	3.7
CMU-N	19	May	82	323	12.6
CMU-N	20	May	213	599	48.8

APPENDIX C Continued.

Management unit division	Week	Month	Nests found	Eggs and nestlings present	Doves fledged
CMU-N	21	May	243	869	110.2
CMU-N	22	May	271	1031	111.3
CMU-N	23	Jun	178	893	152.9
CMU-N	24	Jun	194	898	188.7
CMU-N	25	Jun	153	760	143.9
CMU-N	26	Jun	148	748	141.3
CMU-N	27	Jul	166	708	170.8
CMU-N	28	Jul	146	667	125.8
CMU-N	29	Jul	165	714	113.8
CMU-N	30	Jul	173	740	145.2
CMU-N	31	Jul	126	676	138.4
CMU-N	32	Aug	137	647	145.5
CMU-N	33	Aug	111	518	117.7
CMU-N	34	Aug	128	568	100.5
CMU-N	35	Aug	77	480	107.7
CMU-N	36	Sep	37	308	125.5
CMU-N	37	Sep	12	138	83.9
CMU-N	38	Sep	5	47	42.3
CMU-N	39	Sep	0	10	13.9
CMU-N	40	Oct	0	2	0.0
CMU-N	41	Oct	0	0	1.7
CMU-S	All	All	1184	4676	734.0
CMU-S	11	Mar	4	6	0.0
CMU-S	12	Mar	6	16	0.0
CMU-S	13	Mar	7	23	3.7
CMU-S	14	Apr	8	32	0.0
CMU-S	15	Apr	15	40	3.9
CMU-S	16	Apr	22	67	2.0
CMU-S	18	Apr	47	162	10.3
CMU-S	19	May	54	201	24.5
CMU-S	20	May	97	279	16.9
CMU-S	21	May	85	312	26.3
CMU-S	22	May	70	298	55.2
CMU-S	23	Jun	72	266	43.6
CMU-S	24	Jun	69	272	42.7
CMU-S	25	Jun	78	295	46.4
CMU-S	26	Jun	68	297	36.4
CMU-S	27	Jul	57	278	62.8
CMU-S	28	Jul	58	238	51.2
CMU-S	29	Jul	49	217	36.4
CMU-S	30	Jul	46	203	39.9
CMU-S	31	Jul	39	158	25.3
CMU-S	32	Aug	43	179	23.0
CMU-S	33	Aug	39	168	22.4
CMU-S	34	Aug	28	138	40.0
CMU-S	35	Aug	39	138	35.0
CMU-S	36	Sep	21	125	31.7
CMU-S	37	Sep	17	87	26.8
CMU-S	38	Sep	7	42	11.9
CMU-S	39	Sep	1	16	7.0
CMU-S	40	Oct	0	8	1.9
CMU-S	41	Oct	0	4	2.0
CMU-S	42	Oct	0	0	0.0
WMU	All	All	991	4560	824.1
WMU	12	Mar	2	2	0.0
WMU	13	Mar	2	5	0.0
WMU	14	Apr	4	9	5.3
WMU	15	Apr	21	45	2.0
WMU	16	Apr	17	67	2.4
WMU	17	Apr	10	67	11.1
WMU	18	Apr	36	93	12.6
WMU	19	May	43	136	8.3

APPENDIX C Continued.

Management unit division	Week	Month	Nests found	Eggs and nestlings present	Doves fledged
WMU	20	May	45	192	13.1
WMU	21	May	46	231	34.2
WMU	22	May	57	236	53.8
WMU	23	Jun	101	331	61.2
WMU	24	Jun	83	361	45.8
WMU	25	Jun	76	359	51.6
WMU	26	Jun	56	322	67.1
WMU	27	Jul	70	326	66.3
WMU	28	Jul	64	321	73.0
WMU	29	Jul	74	321	40.3
WMU	30	Jul	38	260	50.5
WMU	31	Jul	60	272	58.2
WMU	32	Aug	35	235	57.2
WMU	33	Aug	28	178	39.5
WMU	34	Aug	11	105	28.8
WMU	35	Aug	7	59	23.9
WMU	36	Sep	3	20	14.4
WMU	37	Sep	2	7	3.5
WMU	38	Sep	0	0	0.0

APPENDIX D

Percentiles of Hatch Dates and Length of Nesting Season for United States and Management Unit Divisions.

Management unit division	Number nests	Min.	Percentiles 5	10	25
US	4019	06 Feb	20 Apr	06 May	28 May
EMU-N	514	23 Mar	11 Apr	21 Apr	06 May
EMU-S	614	06 Feb	16 Mar	01 Apr	28 Apr
CMU-N	1664	21 Apr	15 May	23 May	05 Jun
CMU-S	608	16 Mar	29 Apr	11 May	28 May
WMU	619	26 Mar	26 Apr	13 May	01 Jun

Management unit division	Percentiles 50	75	90	95	Max.	Length
US	26 Jun	30 Jul	23 Aug	01 Sep	19 Oct	109.0
EMU-N	12 Jun	28 Jul	26 Aug	07 Sep	05 Oct	127.0
EMU-S	12 Jun	27 Jul	26 Aug	10 Sep	19 Oct	147.5
CMU-N	04 Jul	03 Aug	25 Aug	31 Aug	27 Sep	94.0
CMU-S	25 Jun	29 Jul	26 Aug	02 Sep	05 Oct	107.0
WMU	26 Jun	22 Jul	10 Aug	17 Aug	07 Sep	89.0

APPENDIX E

Daily Survival Rates and Total Days Observed for Individual Eggs and Nestlings Each Week.

Management unit division	Week	Month	Daily survival rate	Days observed
US	All	All	0.95257	157090.0
US	6	Feb	1.00000	28.0
US	7	Feb	0.91489	47.0
US	8	Feb	0.92727	83.0
US	9	Feb	0.99408	169.0
US	10	Mar	0.94172	429.0
US	11	Mar	0.94876	586.0
US	12	Mar	0.94717	663.0
US	13	Mar	0.93750	864.0
US	14	Apr	0.94264	1430.0
US	15	Apr	0.94884	2229.0
US	16	Apr	0.94954	2795.0
US	17	Apr	0.95759	3348.0
US	18	Apr	0.94982	4364.0
US	19	May	0.95032	5515.0
US	20	May	0.95397	7582.0
US	21	May	0.95128	9422.0
US	22	May	0.94296	9958.0
US	23	Jun	0.95458	9753.0
US	24	Jun	0.94722	9568.0
US	25	Jun	0.95613	9322.0
US	26	Jun	0.95848	9176.0
US	27	Jul	0.94953	8837.0
US	28	Jul	0.95500	8134.0
US	29	Jul	0.95386	8084.0
US	30	Jul	0.95586	7680.0
US	31	Jul	0.95764	7343.0
US	32	Aug	0.95525	6928.0
US	33	Aug	0.95347	5911.0
US	34	Aug	0.95512	5503.0
US	35	Aug	0.95384	4723.0
US	36	Sep	0.95605	3254.0
US	37	Sep	0.94113	1818.0
US	38	Sep	0.95082	915.0
US	39	Sep	0.94980	379.0
US	40	Oct	0.95139	144.0
US	41	Oct	0.95652	69.0
US	42	Oct	0.96364	28.0
US	43	Oct	1.00000	16.0
EMU-N	All	All	0.96708	18408.0
EMU-N	11	Mar	1.00000	4.0
EMU-N	12	Mar	0.91667	24.0
EMU-N	13	Mar	0.94220	173.0
EMU-N	14	Apr	0.96061	457.0
EMU-N	15	Apr	0.94598	778.0
EMU-N	16	Apr	0.96250	1040.0
EMU-N	17	Apr	0.97628	1181.0
EMU-N	18	Apr	0.94904	1119.0
EMU-N	19	May	0.95637	1009.0
EMU-N	20	May	0.98345	967.0
EMU-N	21	May	0.96228	954.5
EMU-N	22	May	0.96960	822.5
EMU-N	23	Jun	0.96041	581.0
EMU-N	24	Jun	0.97692	520.0
EMU-N	25	Jun	0.96433	757.0
EMU-N	26	Jun	0.97471	830.5
EMU-N	27	Jul	0.96010	777.0
EMU-N	28	Jul	0.96313	542.5
EMU-N	29	Jul	0.98145	593.0
EMU-N	30	Jul	0.98137	644.0

APPENDIX E Continued.

Management unit division	Week	Month	Daily survival rate	Days observed
EMU-N	31	Jul	0.96692	665.0
EMU-N	32	Aug	0.97719	701.5
EMU-N	33	Aug	0.96781	683.5
EMU-N	34	Aug	0.96833	663.0
EMU-N	35	Aug	0.98006	652.0
EMU-N	36	Sep	0.97143	455.0
EMU-N	37	Sep	0.97248	327.0
EMU-N	38	Sep	0.98148	270.0
EMU-N	39	Sep	0.94249	156.5
EMU-N	40	Oct	0.94444	36.0
EMU-N	41	Oct	1.00000	26.0
EMU-S	All	All	0.94503	23251.0
EMU-S	6	Feb	1.00000	28.0
EMU-S	7	Feb	0.91489	47.0
EMU-S	8	Feb	0.92727	82.5
EMU-S	9	Feb	0.99408	169.0
EMU-S	10	Mar	0.94172	429.0
EMU-S	11	Mar	0.94876	546.5
EMU-S	12	Mar	0.94184	533.0
EMU-S	13	Mar	0.93416	562.0
EMU-S	14	Apr	0.93657	772.5
EMU-S	15	Apr	0.94464	1011.5
EMU-S	16	Apr	0.92693	958.0
EMU-S	17	Apr	0.95560	946.0
EMU-S	18	Apr	0.93231	916.0
EMU-S	19	May	0.95097	795.5
EMU-S	20	May	0.94447	918.5
EMU-S	21	May	0.95504	912.0
EMU-S	22	May	0.93443	1006.5
EMU-S	23	Jun	0.95179	975.0
EMU-S	24	Jun	0.93937	1072.0
EMU-S	25	Jun	0.93598	984.0
EMU-S	26	Jun	0.95393	955.0
EMU-S	27	Jul	0.93601	1109.5
EMU-S	28	Jul	0.95512	1025.0
EMU-S	29	Jul	0.93529	850.0
EMU-S	30	Jul	0.94942	692.0
EMU-S	31	Jul	0.94350	885.0
EMU-S	32	Aug	0.94770	860.5
EMU-S	33	Aug	0.95284	678.5
EMU-S	34	Aug	0.95826	599.0
EMU-S	35	Aug	0.95745	517.0
EMU-S	36	Sep	0.95316	491.0
EMU-S	37	Sep	0.94050	437.0
EMU-S	38	Sep	0.94979	239.0
EMU-S	39	Sep	0.96330	109.0
EMU-S	40	Oct	0.95455	66.0
EMU-S	41	Oct	0.96552	29.0
EMU-S	42	Oct	0.96364	27.5
EMU-S	43	Oct	1.00000	16.0
CMU-N	All	All	0.95392	66878.0
CMU-N	14	Apr	1.00000	3.0
CMU-N	15	Apr	1.00000	11.0
CMU-N	16	Apr	1.00000	63.0
CMU-N	17	Apr	0.93562	233.0
CMU-N	18	Apr	0.96704	1031.5
CMU-N	19	May	0.95150	1835.0
CMU-N	20	May	0.95338	3196.0
CMU-N	21	May	0.94784	4601.5
CMU-N	22	May	0.94167	5331.5
CMU-N	23	Jun	0.95425	4940.0
CMU-N	24	Jun	0.94914	4699.0

APPENDIX E Continued.

Management unit division	Week	Month	Daily survival rate	Days observed
CMU-N	25	Jun	0.96133	4111.5
CMU-N	26	Jun	0.95762	4034.5
CMU-N	27	Jul	0.95228	3772.0
CMU-N	28	Jul	0.95664	3621.0
CMU-N	29	Jul	0.95283	3816.0
CMU-N	30	Jul	0.96016	3990.5
CMU-N	31	Jul	0.95898	3632.0
CMU-N	32	Aug	0.95523	3216.5
CMU-N	33	Aug	0.95601	2773.5
CMU-N	34	Aug	0.95850	2916.0
CMU-N	35	Aug	0.94913	2516.0
CMU-N	36	Sep	0.96031	1612.5
CMU-N	37	Sep	0.95205	646.5
CMU-N	38	Sep	0.94678	225.5
CMU-N	39	Sep	0.95556	45.0
CMU-N	40	Oct	1.00000	4.0
CMU-S	All	All	0.94065	24482.0
CMU-S	11	Mar	0.94286	35.0
CMU-S	12	Mar	0.97949	97.5
CMU-S	13	Mar	0.94643	112.0
CMU-S	14	Apr	0.91463	164.0
CMU-S	15	Apr	0.94409	232.5
CMU-S	16	Apr	0.92722	343.5
CMU-S	17	Apr	0.95615	638.5
CMU-S	18	Apr	0.94454	865.5
CMU-S	19	May	0.93067	1053.0
CMU-S	20	May	0.93465	1423.0
CMU-S	21	May	0.94517	1732.5
CMU-S	22	May	0.92761	1602.5
CMU-S	23	Jun	0.94278	1415.5
CMU-S	24	Jun	0.93809	1421.5
CMU-S	25	Jun	0.94693	1545.0
CMU-S	26	Jun	0.94705	1586.5
CMU-S	27	Jul	0.93902	1459.5
CMU-S	28	Jul	0.93696	1269.0
CMU-S	29	Jul	0.94763	1107.5
CMU-S	30	Jul	0.92961	966.0
CMU-S	31	Jul	0.94530	841.0
CMU-S	32	Aug	0.94333	900.0
CMU-S	33	Aug	0.93929	873.0
CMU-S	34	Aug	0.95902	756.5
CMU-S	35	Aug	0.95916	759.0
CMU-S	36	Sep	0.94015	601.5
CMU-S	37	Sep	0.90539	380.5
CMU-S	38	Sep	0.91136	180.5
CMU-S	39	Sep	0.94118	68.0
CMU-S	40	Oct	0.94737	38.0
CMU-S	41	Oct	0.85714	14.0
WMU	All	All	0.95713	24072.0
WMU	12	Mar	1.00000	8.0
WMU	13	Mar	0.94118	17.0
WMU	14	Apr	0.96970	33.0
WMU	15	Apr	0.98469	196.0
WMU	16	Apr	0.98205	390.0
WMU	17	Apr	0.91714	350.0
WMU	18	Apr	0.95838	432.5
WMU	19	May	0.96476	823.0
WMU	20	May	0.96286	1077.0
WMU	21	May	0.96151	1221.0
WMU	22	May	0.95816	1195.0
WMU	23	Jun	0.96415	1841.0
WMU	24	Jun	0.94557	1855.5

APPENDIX E Continued.

Management unit division	Week	Month	Daily survival rate	Days observed
WMU	25	Jun	0.95947	1924.5
WMU	26	Jun	0.96553	1769.5
WMU	27	Jul	0.95637	1719.0
WMU	28	Jul	0.96241	1676.0
WMU	29	Jul	0.95983	1717.5
WMU	30	Jul	0.95315	1387.5
WMU	31	Jul	0.96665	1319.5
WMU	32	Aug	0.95678	1249.5
WMU	33	Aug	0.94900	902.0
WMU	34	Aug	0.91381	568.5
WMU	35	Aug	0.91398	279.0
WMU	36	Sep	0.92553	94.0
WMU	37	Sep	0.81132	26.5

APPENDIX F

Study Areas for Determining Effect of Hunting With Opening Dates for Dove Hunting Seasons.

Study area	Hunting state	Opening date of hunting		Paired nonhunting state or zone	Opening date in zone	
		1978	1979		1978	1979
1	NE	9/1	9/1	SD State		
2	NE	9/1	9/1	IA State		
3	MO	9/1	9/1	IA State		
4	IL	9/1	9/1	IN State		
5	KY	9/1	9/1	IN State		
6	PA	9/1	9/1	NJ State		
7	TX	9/1	9/1	TX Zone	9/23	9/22
8	LA	9/2	9/1	LA Zone	10/14	10/15
9	MS	9/2	9/1	MS Zone	9/23	9/22
10	AL	9/16	9/15	AL Zone	10/7	10/6
11	GA	9/2	9/1	GA Zone	9/30	9/29

APPENDIX G

Stratum Combinations for Both Years Within Each Study Area for Obtaining a Minimum of 20 Days Exposure in the Hunted and Nonhunted Zones of Each Stratum.

Study Area		Stratum combinations	
Hunted	Nonhunted	Not pooled[a]	Pooled[b]
Paired states			
IL	IN	1,2-4,5,6,7,8,9,10,11,12	1-6,7-12
KY	IN	1-2,3,4,5,6,7,8-11,12	1-12
MO	IA	1-3,4,5-9,10,11-12	1-12
NE	IA	1,2,3,4,5,6,7,8,9-10, 11,12	1-6,7-12
NE	SD	1-4,5,6-7,8,9,10,11-12	1-6,7-12
PA	NJ	1-2,3-4,5,6-8,9,10,11,12	1-6,7-12
Zoned states			
AL		1-11,12	1-12
GA		1,2,3,4,5-6,7-12	1-12
LA		1,2-4,5,6-12	1-12
MS		1-6,7-8,9-12	1-6 with LA 7-12 with AL
TX		1,2,3-4,5-6,7-12	1-12

[a]Used in paired t-test (Table 10), analysis of variance (Table 12), and sign test (Table 13).

[b]Used in analysis of variance (Table 12).

APPENDIX H

Power of Weighted Paired t-test to Detect Effects of Hunting on Daily Survival Rates.

S. Lynne Stokes
U.S. Fish and Wildlife Service

No method of power analysis is currently available for the weighted analysis of variance or for the weighted paired t-test. It was necessary to develop a power analysis for a weighted paired t-test in order to estimate the power of our experiment to detect effects of hunting on the survival of eggs and nestlings. Let S_i and S_i^* denote the daily survival rates in the hunted and nonhunted sections of the strata, $i = 1,\ldots,N$. We derive a test of the hypothesis:

$$H_o : S_i - S_i^* = 0 \text{ vs. } H_a : S_i - S_i^* < 0$$

Note that our null hypothesis allows for the possibility that survival rates within the hunted and nonhunted sections may differ among areas but that interaction is negligible.

Hensler and Nichols (1981) examined Mayfield's (1961) estimator $\hat{p}$ of daily nest survival rate and proved, under certain distributional assumptions, the following properties:

(1) $\hat{p}$ is the maximum likelihood estimator of p.

(2) A reasonable large sample estimator of the variance of $\hat{p}$ is $\hat{p}(1-\hat{p})/n$ where n is the total number of nest days observed. Note that although the variance is the same as the variance of the binomial $\hat{p}$, the Hensler-Nichols model was based on a truncated geometric distribution.

The second result allows us to transform and weight our observations of nest daily survival rates so as to equalize their variances. Equal variances of observations are required in normal theory procedures such as the t-test and analysis of variance. Consider the statistic

$$T=N^{-1/2}\sum_{i=1}^{N} d_i/[\sum_{i=1}^{N}(d_i-\bar{d})^2/(N-1)]^{1/2}$$

where

$$d_i=[(n_i+n_i^*)/(n_i n_i^*)]^{-1/2}(\arcsin \hat{S}_i^{1/2}-\arcsin \hat{S}_i^{*1/2}).$$

If (2) above applies to $\hat{S}_i$, then $\arcsin \hat{S}_i^{1/2}$ has asymptotic mean $\arcsin S_i^{1/2}$ and asymptotic variance σ^2/n_i where n_i is the number of egg or nestling days observed in the nonhunted sections of the ith stratum (Snedecor and Cochran 1980:290). A similar statement is true for $\hat{S}_i^*$ as an estimate of survival rate in the presence of hunting. Thus, if H_o is true, the numerator of T will be approximately normal with mean 0 and variance σ^2, while the denominator is an estimate of σ. If d_i is close enough to normal, then $T \sim t_{N-1}$ under H_o. Thus, the statistic T is that of a 1-sample t-test applied to the N "observations" d_i, and the test becomes "Reject H_o if $T > t_{N-1,1-\alpha}$."

The power function of the test T is

$$B(\delta) = P[\text{rejecting } H_o \mid \delta'=\delta,\ i=1,\ldots,N]$$
$$= P[T>t_{N-1,1-\alpha} \mid \delta'=\delta,\ i=1,\ldots,N]$$

where $\delta' = \arcsin S_i^{1/2} - \arcsin S_i^{*1/2}$.
When $\delta' = \delta$, the distribution of T is that of a random variable where the numerator is normally distributed with mean

$$N^{-1/2} \sum_{i=1}^{N} [(n_i + n_i^*)/(n_i n_i^*)]^{-1/2} \delta$$

and variance σ^2 and where the denominator is

$[\sigma^2 \chi^2_{N-1}/(N-1)]^{1/2}$. The numerator and

denominator are independent. Thus

$$T \sim t_{N-1}\{\lambda = N^{-1/2} \sum_{i=1}^{N} [(n_i + n_i^*)/(n_i n_i^*)]^{-1/2} \delta/\sigma\}$$

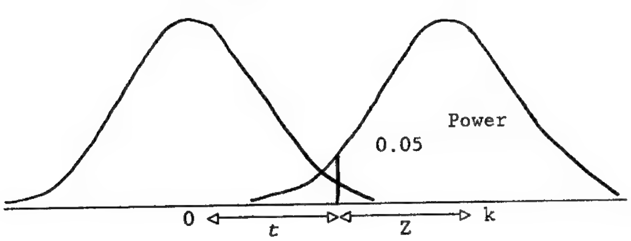
(a non-central t with non-centrality parameter λ). In our case, N = 69, so that the non-central t is well approximated by a normal with mean λ and variance 1.

The above weighting was developed for nest daily survival rate assuming that the variance was proportional to the Hensler-Nichols variance estimate, which assumes that the fates of the observed nests are independent. Although we cannot assume the same about eggs or nestlings within the same nest, the weighting is still appropriate if the fate of both eggs or nestlings in the same nest is perfectly correlated because the variance is then proportional to the Hensler-Nichols variance estimate.

To find the differences which we can reliably detect with the paired t-test, we need to find δ such that

$p(\text{rejecting } H_o \mid H_a) = P[(T > t_{N-1,1-\alpha} \mid t \sim N(\lambda, 1)]$
equals the specified power, where $t_{N-1,1-\alpha}$ is the critical t value used in the test. Testing the critical values for our one-tailed test at the significance level ($p = 0.05$) is $t_{68,0.95} = 1.668$. Diagrammatically, the situation is

$H_o: T \sim t_{N-1}$ $\qquad$ $H_a: T \sim N(\lambda, 1)$



Here Z is found in a normal table such that the test will have the specific power. From the diagram we see that $\lambda = t + Z$. We have calculated λ to be 60.878 δ, 55.683 δ, and 63.305 δ, respectively for individual and for the first lost and the all lost definitions of nest survival. For a power of 0.80, Z = 0.842; For a significance level of 0.05, t=1.668. Then for individuals, $\lambda = 60.878\ \delta$ and $\lambda = 1.668 + 0.842$. Solving, $\delta = (1.688 + 0.842)/60.878 = 0.04123$. This is a difference detectable on the transformed scale. If the daily survival rate in all the nonhunted sections S^*, is 0.96 then the rate in the hunted portion that would be detectable with this power (0.80) is $\arcsin\ S^{*1/2} - \delta = 1.36944 - 0.04123 = 1.32821 = S'$. Back transforming S' as $(\sin S')^2$ yields 0.942 as the daily survival rate in the hunted portion which could be detected with this power (0.80).

Appendix I. Mean Squares From Analyses of Variance. Indention indicates the subdivision of a source.

(1). Mean squares from analysis of variance of seasonal percent of annual total of nests first found (Table 1).

Source	Df	Spring	Summer	Fall
Management unit division	4	49.179	50.802	3.474
North vs. south	1	8.889	10.311	1.187
EMU vs. CMU	1	125.837	123.233	2.421
(N. vs. s.)*(EMU vs. CMU)	1	5.841	5.747	0.329
WMU vs. other divisions	1	22.171	32.630	9.748
State within division (error for above)	19	3.905	3.500	0.987

(2). Mean squares from analysis of variance of seasonal percent of annual total of eggs laid (based on backdating from those eggs that survived to hatching) (Table 2).

Source	Df	Spring	Summer	Fall
Management unit division	4	38.920	45.909	5.677
North vs. south	1	8.090	8.957	0.426
EMU vs. CMU	1	98.635	116.448	13.297
(N. vs. s.)*(EMU vs. CMU)	1	3.740	4.466	0.403
WMU vs. other divisions	1	15.986	21.061	7.532
State within division (error for above)	19	5.591	5.277	0.507

(3). Mean squares from analysis of variance of seasonal percent of annual total of weekly counts of individual eggs or nestlings present (Table 3).

Source	Df	Spring	Summer	Fall
Management unit division	4	216.542	200.069	24.256
North vs. south	1	61.795	41.686	0.023
EMU vs. CMU	1	523.369	454.386	7.959
(N. vs. s.)*(EMU vs. CMU)	1	16.123	15.308	3.357
WMU vs. other divisions	1	106.678	208.035	92.903
State within division (error for above)	19	14.603	11.999	4.824

(4). Mean squares from analysis of variance of 10th, 50th (median), and 90th percentiles of hatch dates for first egg in nests and the length of the nesting season (Table 4).

Source	Df	10th Pctile	Median	90th Pctile	Length
Mgt. unit div.	4	5555.23	1664.83	254.10	6568.12
North vs. south	1	3331.06	141.79	25.38	3938.01
EMU vs. CMU	1	13035.62	3728.90	22.29	11979.85
(N-S)*(EMU-CMU)	1	73.93	2706.97	384.18	795.19
WMU vs. others	1	1799.17	300.12	509.41	4223.28
State	19	352.48	686.22	357.23	616.50
(error for above)					

(5). Mean squares from analysis of variance of seasonal percent of annual total of doves fledged (Table 5).

Source	Df	Spring	Summer	Fall
Management unit division	4	40.515	22.829	6.726
North vs. south	1	14.957	3.734	0.285
EMU vs. CMU	1	107.314	48.913	0.127
(N. vs. s.)*(EMU vs. CMU)	1	0.265	0.916	0.039
WMU vs. other divisions	1	5.517	36.888	25.600
State within division	19	1.838	1.123	1.187
(error for above)				

(6). Mean squares from analysis of variance of daily survival rates of individual eggs and nestlings (Table 6).

Source	Df	Daily Survival Rate
Management unit division	4	4.6414
North vs. south	1	12.8809
EMU vs. CMU	1	8.7581
(N. vs. s.)*(EMU vs. CMU)	1	1.1468
WMU vs. other units	1	0.0025
State within divisions	19	2.9039
(error for above)		
Season	3	0.3344
Season division	12	0.7826
Season State within division	53	0.8099
(error for above)		

(7). Mean squares from analysis of variance of daily survival rates of eggs and nestlings in hunted and nonhunted zones (Table 12).[a]

Pooling years and stages, strata remain separate.

Source	Error Term[b]	Df	Individual Survival	Nest Survival First Lost[c]	Nest Survival All Lost[d]
1 Area	2	10	1.262	1.258	1.176
2 Strata (w/i A)		58	0.429	0.437	0.460
3 Hunt	4	1	0.897	0.901	1.001
4 A * H	5	10	0.699	0.751	0.681
5 S * H (w/i A)		58	0.559	0.693	0.511

Pooling strata; years and stages remain separate.

Source	Error Term[b]	Df	Individual Survival	Nest Survival First Lost[c]	Nest Survival All Lost[d]
1 Area		13	1.124	0.632	0.621
2 Hunt	3	1	0.307	0.129	0.176
3 A * H		13	0.616	0.367	0.379
4 Stage	5	1	5.286	2.475	2.641
5 A * S		13	0.384	0.215	0.179
6 H * S	7	1	1.134	0.443	0.652
7 A * H * S		13	0.561	0.283	0.206
8 Year	9	1	0.291	0.153	0.145
9 A * Y		13	0.938	0.452	0.454
10 H * Y	11	1	0.005	0.000	0.000
11 A * H * Y		13	0.820	0.411	0.523
12 Y * S	13	1	0.582	0.228	0.398
13 A * Y * S		13	0.168	0.072	0.111
14 H * Y * S	15	1	0.404	0.217	0.185
15 H * Y * S * A		13	0.420	0.141	0.290

[a] The angular transformation was used to stabilize the variance, and the analysis was weighted by the number of egg and nestling days observed for individual survival and by nest days for nest survival.
[b] Error term used for each source is indicated by the line number in this column.
[c] Nest recorded lost when first individual lost.
[d] Nest recorded lost when all individuals lost.

Geissler, Paul H., David D. Dolton, Rebecca Field, Richard A. Coon, H. Franklin Percival, Don W. Hayne, Lawrence D. Soileau, Ronnie R. George, James H. Dunks, S. Dwight Bunnell. 1987. **Mourning Dove Nesting: Seasonal Patterns and Effects of September Hunting.** U.S. Fish Wildl. Serv., Resour. Publ. 168. 33 pp.

A nationwide State–Federal cooperative study was initiated in 1978 to examine effects of September hunting on nesting mourning doves (*Zenaida macroura*). This study was designed to (1) determine the proportion of the annual total of dove nesting activity and production that occurs in September and October, and (2) determine if survival rates of mourning dove eggs and nestlings are lower in zones where early September dove hunting is permitted than in zones where it is prohibited.

Key words: *Zenaida macroura*, Columbidae, sport hunting, hunting regulations, dove reproduction, population models, nesting seasons, survival rates.

Geissler, Paul H., David D. Dolton, Rebecca Field, Richard A. Coon, H. Franklin Percival, Don W. Hayne, Lawrence D. Soileau, Ronnie R. George, James H. Dunks, S. Dwight Bunnell. 1987. **Mourning Dove Nesting: Seasonal Patterns and Effects of September Hunting.** U.S. Fish Wildl. Serv., Resour. Publ. 168. 33 pp.

A nationwide State–Federal cooperative study was initiated in 1978 to examine effects of September hunting on nesting mourning doves (*Zenaida macroura*). This study was designed to (1) determine the proportion of the annual total of dove nesting activity and production that occurs in September and October, and (2) determine if survival rates of mourning dove eggs and nestlings are lower in zones where early September dove hunting is permitted than in zones where it is prohibited.

Key words: *Zenaida macroura*, Columbidae, sport hunting, hunting regulations, dove reproduction, population models, nesting seasons, survival rates.

Geissler, Paul H., David D. Dolton, Rebecca Field, Richard A. Coon, H. Franklin Percival, Don W. Hayne, Lawrence D. Soileau, Ronnie R. George, James H. Dunks, S. Dwight Bunnell. 1987. **Mourning Dove Nesting: Seasonal Patterns and Effects of September Hunting.** U.S. Fish Wildl. Serv., Resour. Publ. 168. 33 pp.

A nationwide State–Federal cooperative study was initiated in 1978 to examine effects of September hunting on nesting mourning doves (*Zenaida macroura*). This study was designed to (1) determine the proportion of the annual total of dove nesting activity and production that occurs in September and October, and (2) determine if survival rates of mourning dove eggs and nestlings are lower in zones where early September dove hunting is permitted than in zones where it is prohibited.

Key words: *Zenaida macroura*, Columbidae, sport hunting, hunting regulations, dove reproduction, population models, nesting seasons, survival rates.

Geissler, Paul H., David D. Dolton, Rebecca Field, Richard A. Coon, H. Franklin Percival, Don W. Hayne, Lawrence D. Soileau, Ronnie R. George, James H. Dunks, S. Dwight Bunnell. 1987. **Mourning Dove Nesting: Seasonal Patterns and Effects of September Hunting.** U.S. Fish Wildl. Serv., Resour. Publ. 168. 33 pp.

A nationwide State–Federal cooperative study was initiated in 1978 to examine effects of September hunting on nesting mourning doves (*Zenaida macroura*). This study was designed to (1) determine the proportion of the annual total of dove nesting activity and production that occurs in September and October, and (2) determine if survival rates of mourning dove eggs and nestlings are lower in zones where early September dove hunting is permitted than in zones where it is prohibited.

Key words: *Zenaida macroura*, Columbidae, sport hunting, hunting regulations, dove reproduction, population models, nesting seasons, survival rates.

☆ U.S. Government Printing Office: 1987—772-205/60023

A list of current *Resource Publications* follows

157. The Breeding Bird Survey: Its First Fifteen Years, 1965–1979, by Chandler S. Robbins, Danny Bystrak, and Paul H. Geissler. 1986. 196 pp.
158. Techniques for Studying Nest Success of Ducks in Upland Habitats in the Prairie Pothole Region, by Albert T. Klett, Harold F. Duebbert, Craig A. Faanes, and Kenneth F. Higgins, 1986. 24 pp.
159. Research and Development Series: An Annotated Bibliography, 1889–1985, compiled by Thomas J. Cortese and Barbara A. Groshek. In press.
160. Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals, by Foster L. Mayer and Mark R. Ellersieck. 1986. 579 pp.
161. Interpretation and Compendium of Historical Fire Accounts in the Northern Great Plains, by Kenneth F. Higgins. 1986. 39 pp.
162. Population Ecology of the Mallard. VIII. Winter Distribution Patterns and Survival Rates of Winter-Banded Mallards, by James D. Nichols and James E. Hines. 1987. 154 pp.
163. Forested Wetlands of the Southeast: Review of Major Characteristics and Role in Maintaining Water Quality, by Parley V. Winger. 1986. 16 pp.
164. Effects of Contaminants on Naiad Mollusks (Unionidae): A Review, by Marian E. Havlik and Leif L. Marking. 1987. 20 pp.
165. Marking and Tagging of Aquatic Animals: An Indexed Bibliography, by Lee Emery and Richard Wydoski. 1987. 57 pp.
166. Checklist of Vertebrates of the United States, the U.S. Territories, and Canada, by Richard C. Banks, Roy W. McDiarmid, and Alfred L. Gardner. 1987. 79 pp.
167. Field Guide to Wildlife Diseases. Vol. 1. General Field Prodedures and Diseases of Migratory Birds, by Milton Friend, Cynthia J. Laitman, and Randy Stothard Kampen. 1987.

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
OFFICE OF INFORMATION TRANSFER
1025 PENNOCK PLACE, SUITE 212
FORT COLLINS, COLORADO 80524

THIRD-CLASS MAIL
POSTAGE AND FEES PAID
U.S. DEPARTMENT OF THE INTERIOR
PERMIT NO. G-77

NOTE: Mailing lists are computerized. Please return address label with change of address.